TECHNICAL REPORT

Proposed Changes to Sacramento Peak Observatory Operations: Historic Properties Assessment of Effects

Prepared for

National Science Foundation

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Acronyms and Abbreviations

ACHP	Advisory Council on Historic Preservation
APE	Area of Potential Effects
ARC	Astrophysical Research Consortium
AST	Division of Astronomical Sciences
CE	Civil Engineering
C.F.R.	*Code of Federal Regulations*
DKIST	Daniel K. Inouye Solar Telescope
DST	Richard B. Dunn Solar Telescope
GRD	Geophysics Research Directorate
HAO	High Altitude Observatory
HCPI	Historic Cultural Property Inventory
ISOON	Improved Solar Observing Optical Network
MOA	Memorandum of Agreement
NCAR	National Center for Atmospheric Research
NHPA	National Historic Preservation Act
NMSU	New Mexico State University
NRHP	National Register of Historic Places
NSF	National Science Foundation
NSO	National Solar Observatory
PA	Programmatic Agreement
SHPO	State Historic Preservation Officer
SOON	Solar Observing Optical Network
TCP	Traditional Cultural Property
U.S.C.	United States Code
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VLA	Very Large Array
WPA	Works Progress Administration

SECTION 1

Introduction

The National Science Foundation (NSF) has identified the need to divest several facilities from its portfolio to retain the balance of capabilities needed to deliver the best performance on the key science of the present decade and beyond. Sacramento Peak Observatory in Sunspot, Otero County, New Mexico, is one of the facilities identified for potential changes in operation. This technical report describes the undertaking and its proposed Alternatives, presents archaeological and architectural identifications and evaluations, and provides an assessment of effects associated with the undertaking.

1.1 Definition of Proposed Undertaking

The decision regarding the potential changes to Sacramento Peak Observatory operations is considered a federal undertaking and triggers compliance with Section 106 (54 United States Code Section [U.S.C. §] 306108) of the National Historic Preservation Act of 1966, as amended (54 U.S.C. § 300101 *et seq*.) (NHPA) and the NHPA's implementing regulations, "Protection of Historic Properties" (Title 36 *Code of Federal Regulations* [C.F.R.] Part 800). NSF initiated Section 106 consultation with the New Mexico State Historic Preservation Officer (SHPO) on August 24, 2016. Consultation with SHPO is ongoing.

1.2 Proposed Alternatives Background

The Sacramento Peak Observatory is located within the Lincoln National Forest in the Sacramento Mountains. The project area is located on National Forest System lands managed by the U.S. Department of Agriculture, U.S. Forest Service (USFS), Lincoln National Forest, and Sacramento Ranger District. Established by the U.S. Air Force via a Memorandum of Agreement (MOA) with the USFS in 1950, the facility was transferred to NSF in 1976. NSF and the USFS executed a land use agreement, signed in 1980, to formalize this transfer and the continued use of the land for the Observatory. The flagship facility at the Sacramento Peak Observatory is the Richard B. Dunn Solar Telescope (DST), previously known as the Vacuum Tower Telescope, which was completed in 1969 and is a high spatial resolution optical solar telescope, allowing solar astronomers worldwide to obtain information about the Sun. In addition to the DST, Sacramento Peak Observatory hosts the John W. Evans Solar Facility (1952; not in active use), the Hilltop Dome (1963; not in active use), the Grain Bin Dome (1950; not in active use), and the Patrol Dome, as well as various support structures.

In 2015, CH2M conducted a cultural resources survey of the architectural resources at the Sacramento Peak Observatory. A summary of the survey results is included in Section 2.2, "Determinations of Eligibility." The associated technical report, titled *Cultural Resources Evaluation, National Solar Observatory (Sacramento Peak Observatory), Sunspot, New Mexico*, was submitted to the New Mexico SHPO for review on August 24, 2016 (CH2M, 2016). The New Mexico SHPO concurred with NSF's determinations of eligibility on May 18, 2017.

1.3 Proposed Alternatives Description

NSF's Division of Astronomical Sciences (AST) is the federal steward for ground-based astronomy in the United States, funding research through awards to individual investigators and research groups and via cooperative agreements for operation of telescope facilities. These national and international telescope facilities provide observational capabilities on a competitive basis to thousands of astronomers per year. These facilities also enable scientific advances by making archived data products available to researchers. Along with funding telescope facilities and research awards, AST supports the development of advanced technologies and instrumentation. One area of research supported by AST is solar

astronomy, which is primarily managed via the National Solar Observatory (NSO). NSO-managed facilities include the Sacramento Peak Observatory.

The need for NSF to reduce its participation in the Sacramento Peak Observatory has been established through a number of reviews and surveys conducted by the science community. At present, the Sacramento Peak Observatory serves the solar physics community as the only high-resolution solar facility with extensive spectroscopic capabilities open for community access in the United States and as a development test bed for the high-order Adaptive Optics capability. The 4-meter-diameter Daniel K. Inouye Solar Telescope (DKIST) is currently under construction on Haleakalá in Maui, Hawai'i, and is planned to replace the function of DST for NSO. In a funding-constrained environment, NSF needs to maintain a balanced research portfolio. Therefore, the purpose of this proposed undertaking is to allow NSF to substantially reduce its contribution to the funding of Sacramento Peak Observatory. NSF has proposed four alternatives to address the need to substantially reduce NSF's contribution from its current level to a level that retains a balanced program overall for ground-based astronomy.

Use or demolition of any particular building or instrument cannot be determined unless or until a viable collaboration option is under consideration. Because reduction of NSF funding may require mothballing or demolition of facilities, this technical report describes these Alternatives under the most conservative (greatest effect) scenario in terms of NSF's analysis of potential changes to facilities, so that it may be inclusive of the full range of potential effects to historic properties. The four proposed Alternatives and the No-Action Alternative are described as follows:

- **Alternative 1** – **Continued Science- and Education-focused Operations by Interested Parties with Reduced NSF Funding**: Alternative 1 would involve the transition of site operations of the Sacramento Peak Observatory to interested parties for continued solar astronomy research. NSF would reduce funding of the Sacramento Peak Observatory and the interested parties would be responsible for future maintenance and any future upgrades. Alternative 1 would involve the least change to the current facility and the majority of the telescopes and related research and support facilities would be kept and maintained. The Residential House Trailer (a non-historic structure) and 21 Relocatable Housing units (including the Recreation House) could potentially be demolished under this proposed Alternative.
- **Alternative 2 – Transition to Partial Operations by Interested Parties with Reduced NSF Funding**: Alternative 2 would involve transition of partial operations of the Sacramento Peak Observatory to interested parties. Operations would continue to focus on scientific research and Science, Technology, Engineering, and Mathematics (STEM) education. NSF would reduce funding of the Sacramento Peak Observatory and the additional interested parties would be responsible for future maintenance and any future upgrades. Facilities not needed to meet the anticipated operational goals of the interested parties would be mothballed or demolished. The Residential House Trailer (a non-historic structure) and 21 Relocatable Housing units (including the Recreation House) could potentially be demolished under this proposed Alternative.
- **Alternative 3 – Mothballing of Facilities**: Alternative 3 would involve mothballing and preserving facilities for the purpose of maintaining operational readiness in the event a new operator is identified. This includes mothballing all buildings, with the exception of the Residential House Trailer (a non-historic structure) and 21 Relocatable Housing units (including the Recreation House), which could potentially be demolished under this proposed Alternative. Mothballing activities involve removing a facility from daily use while maintaining the general condition of equipment and structures. The intent is to preserve the equipment and structures such that operations could be restarted at some future date without requiring significant repairs. At this time, it is not known what type of operations would be implemented after the mothball period ends or the length of the mothballing period, but it is assumed that operations would be similar to the scientific research and educational activities currently occurring at the Sacramento Peak Observatory, with no major

change in land use. Mothballing would not occur indefinitely, as it is inconsistent with NSF's mission and science priorities to maintain mothballed buildings in perpetuity. If no viable options are identified for operations to be transferred to a new operator, NSF would consider other methods of disposition in coordination with USFS and would complete any additional required environmental analysis at that time, if necessary.

- **Alternative 4 – Demolition and Site Restoration**: Alternative 4 could involve the removal of all structures to a maximum of 4 feet below existing ground surface grade to enable the restoration of the ground surface topography without limiting future surface operations or activities. All above-grade structures could be removed and demolished, with below-grade structures and foundations stabilized, filled, and abandoned in place. Safe demolition of the aboveground portion of the DST would be accomplished using explosives (in the form of shaped charges, single detonation event) and conventional demolition equipment, and it would be conducted in accordance with a Blast Management Plan developed to identify and control safety risks associated with blasting. Excavated areas would be reclaimed using fill materials that are free of known contaminants.
- **No-Action Alternative – Continued NSF Investment for Science-focused Operations**: Under the No-Action Alternative, NSF would continue to fund the Sacramento Peak Observatory at current levels. None of the proposed Action Alternatives would be implemented.

These proposed Alternatives may be further refined during the compliance review process and will be informed by public comment and the Section 106 consultation process.

1.4 Area of Potential Effects

The area of potential effects (APE) for the proposed undertaking is defined as Sacramento Peak Observatory's overall property limits, which include: the main Observatory area; the Sewage Treatment Plant and associated water wells, as well as the section of Sunspot Highway that connects this area to the main Observatory; and the remains of the helicopter landing area northwest of the Observatory. The Observatory's overall property limits are defined in the land use agreement executed between NSF and USFS in 1980 as the Compound Area. SHPO proposed that the Compound Area (overall property limits) should be used as the APE and NSF agreed. The total acreage of the APE is approximately 250 acres, with approximately 83 acres developed and the remaining acreage undeveloped. The cultural resources survey was conducted in those areas where buildings or roads associated with the Sacramento Peak Observatory are present. The APE is located within U.S. Geological Survey (USGS) Topographic Quadrangle Map Sacramento Peak (2013) (Figure 1).

1.5 Methodology

1.5.1 Determinations of Eligibility

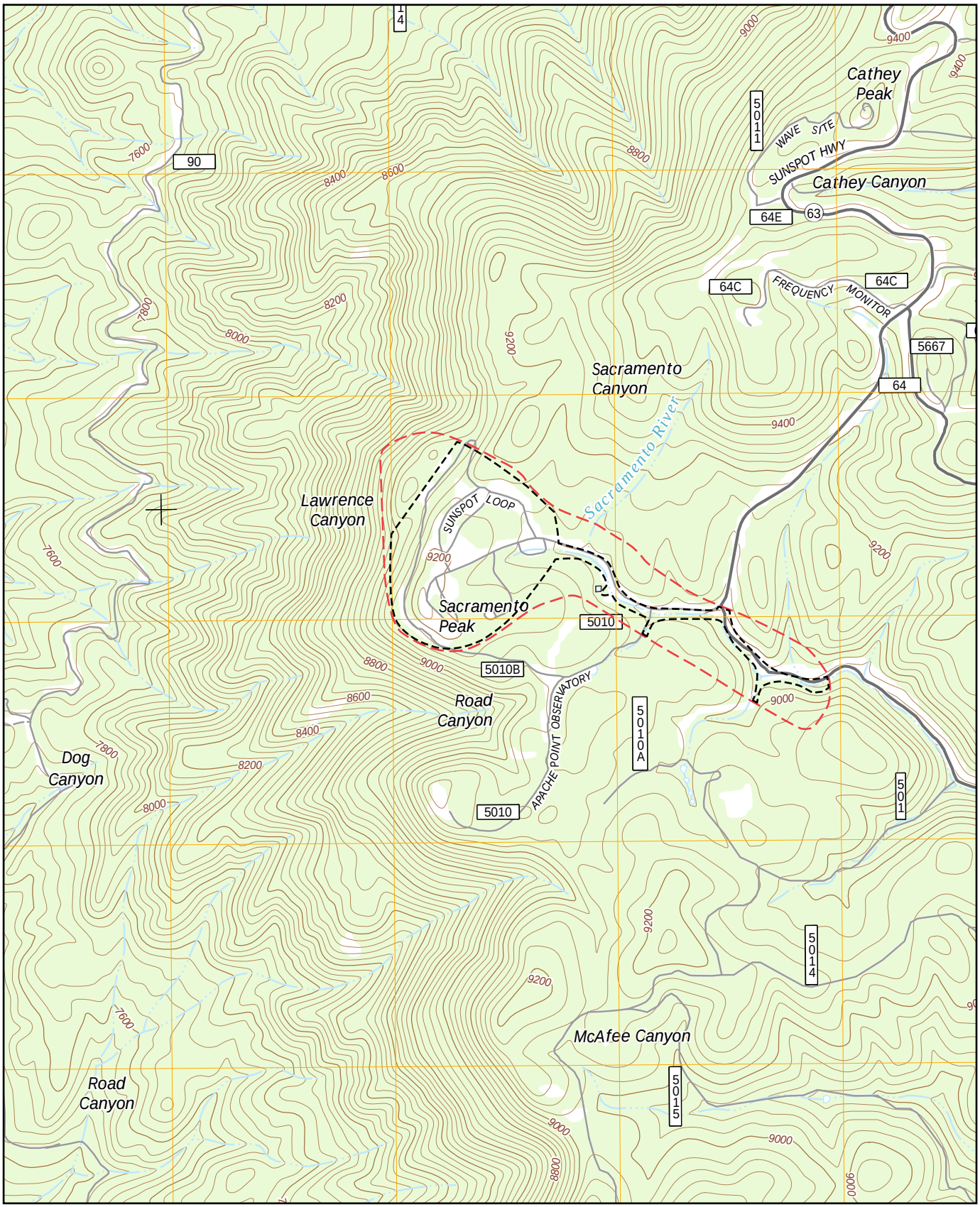
The federal historic properties database known as the National Register Information System was reviewed to identify existing historic properties within the APE. A Secretary of the Interior-qualified architectural historian conducted an intensive architectural survey at the Sacramento Peak Observatory on January 26 and 27, 2015. The survey was used to engage staff in informal interviews and to conduct archival research, including reviews of historic photographs and narratives, newspaper articles, construction records, former surveys, environmental documentation, and architectural drawings.

Historic architectural resources within the APE were evaluated for potential eligibility for listing in the National Register of Historic Places (NRHP), both individually and as a potential historic district. The evaluation included all facilities that were more than 45 years old at the time of the survey. The standard NRHP age threshold is 50 years; however, using 45 years as the cutoff allows a 5-year buffer for the execution of any proposed Alternative. Sacramento Peak Observatory contains some buildings that

were constructed after 1970, such as the visitors' center, a storage building, and some trailers; however, they are not considered to have exceptional importance and do not qualify under NRHP Criteria Consideration G, which applies to properties that have achieved significance within the last 50 years. A total of 65 built environment resources that had been constructed in or before 1970 were identified as extant within the APE, including 5 telescope structures, 35 residential buildings, 17 administrative buildings, and 8 buildings and structures associated with site infrastructure (Figure 2). Appendix A includes a table listing all the buildings and structures that were evaluated for the NRHP as part of the 2015 intensive architectural survey.

Buildings and structures that were not 45 years old at the time of the cultural resources survey and were not considered to have exceptional importance were not included in the historic district evaluation and are not listed in Appendix A. The Post Office located within the main Sacramento Peak Observatory area, which was more than 45 years old at the time of the survey, was not included in the cultural resources survey because it is not owned by NSF (the Fire Station within the Sacramento Peak Observatory is also not owned by NSF but is less than 45 years old).

NSF initiated Section 106 consultation with the New Mexico SHPO on August 24, 2016. New Mexico Historic Cultural Property Inventory (HCPI) base forms were completed for the 65 built environment resources that were surveyed. The HCPI base forms were submitted to the New Mexico SHPO for review and concurrence on December 20, 2016. Per SHPO's request, the forms were revised and resubmitted to the New Mexico SHPO on April 27, 2017. The New Mexico SHPO concurred with the determinations of eligibility on May 18, 2017.



Source: USGS Sacramento Peak quadrangle - 2013

North

0 1,000 2,000

Approximate scale in feet

LEGEND

Sacramento Peak Observatory NRHP-Eligible Historic District Boundary

Area of Potential Effects (APE)

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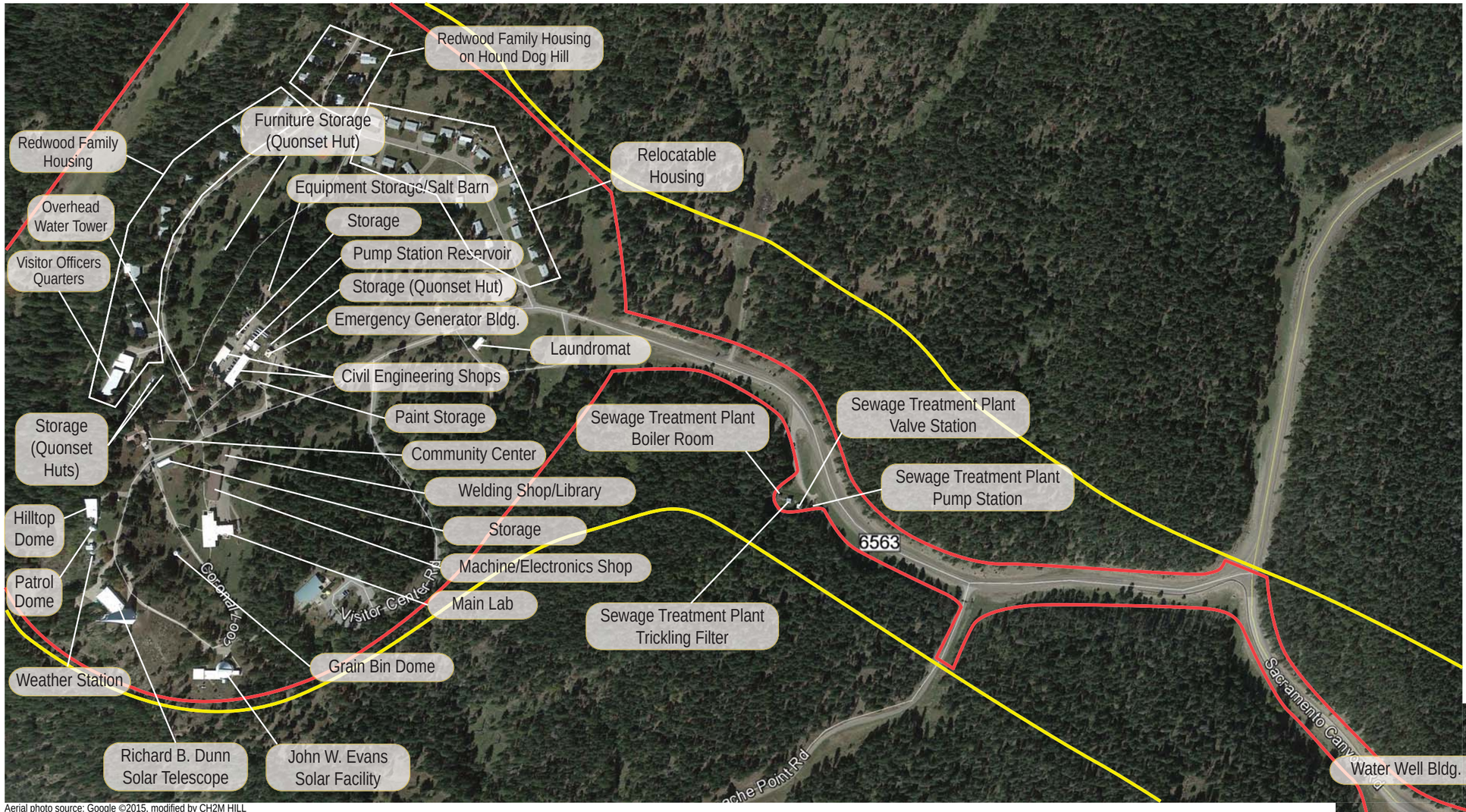
FIGURE 1

Area of Potential Effects (APE)

Sacramento Peak Observatory

Sunspot, New Mexico



Aerial photo source: Google ©2015, modified by CH2M HILL

Building/Structure Name (Building Number)

ADMINISTRATIVE BUILDINGS

- Main Lab (3004)
- Machine/Electronics Shop (3005)
- Welding Shop/Library (3006)
- Storage (Quonset Hut) (3008)
- Community Center (former Mess Hall) (3010)
- Storage (Quonset Hut) (3011)
- Storage (Quonset Hut) (3012)
- Storage Building (3024)
- Furniture Storage (Quonset Hut) (3029)
- Civil Engineering (CE) Shop (3031)
- CE Shop (3032)
- Paint Storage (3034)
- Equipment Storage/Salt Barn (3036)
- Storage (3037)
- Emergency Generator Building (3038)
- Weather Station (3039)
- Laundromat [formerly public restrooms] (3060)

INFRASTRUCTURE

- Pump Station Reservoir (3033)
- Water Well Building (3050)
- Water Well Building (3051)
- Sewage Treatment Plant - Boiler Room (3053)
- Sewage Treatment Plant - Trickling Filter (3054)
- Sewage Treatment Plant - Valve Station (3055)
- Sewage Treatment Plant - Pump Station (3056)
- Overhead Water Tower (no building number)

Building/Structure Name (Building Number)

TELESCOPES

- Grain Bin Dome (3002)
- John W. Evans Solar Facility [housed in the Big Dome] (3000)
- Patrol Dome (ISOON Building) (3009)
- Hilltop Dome (3040)
- Richard B. Dunn Solar Telescope (formerly Vacuum Tower Telescope) (3042)

HOUSING

- Visitor Officers Quarters (VOQ) (3013)
- Redwood Family Housing (3014ns)
- Redwood Family Housing [aka Director's House] (3015)
- Redwood Family Housing (3016ns)
- Redwood Family Housing (3017)
- Redwood Family Housing (3018)
- Redwood Family Housing (3019)
- Redwood Family Housing (3020ns)
- Redwood Family Housing on Hound Dog Hill (3044)
- Redwood Family Housing on Hound Dog Hill (3045)
- Redwood Family Housing on Hound Dog Hill (3046)
- Redwood Family Housing on Hound Dog Hill (3047)
- Redwood Family Housing on Hound Dog Hill (3048)
- Redwood Family Housing on Hound Dog Hill (3049)
- Relocatable Housing (3061)
- Relocatable Housing (3062)
- Relocatable Housing (3063)
- Relocatable Housing (3064)
- Relocatable Housing (3065)
- Relocatable Housing (3066)
- Relocatable Housing (3067)
- Relocatable Housing (3068)
- Relocatable Housing (3069)
- Relocatable Housing (3070), Recreation House
- Relocatable Housing (3071)
- Relocatable Housing (3072)
- Relocatable Housing (3073)
- Relocatable Housing (3074)
- Relocatable Housing (3075)
- Relocatable Housing (3076)
- Relocatable Housing (3077)
- Relocatable Housing (3079)
- Relocatable Housing (3081)
- Relocatable Housing (3083)
- Relocatable Housing (3085)

North

0 250 500

Approximate scale in feet

LEGEND

- NRHP Contributing
- NRHP Non-Contributing
- NRHP Individually Eligible
- NRHP Not Individually Eligible
- Sacramento Peak Observatory NRHP-Eligible Historic District Boundary
- Area of Potential Effects (APE)

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FIGURE 2
Surveyed Built Environment Resources
Sacramento Peak Observatory
Sunspot, New Mexico

1.5.2 Finding of Effect

As stipulated in 36 C.F.R. 800.1(a), the goal of consultation is to identify historic properties potentially affected by the undertaking, assess the effects to them, and seek ways to avoid, minimize, or mitigate any adverse effects on historic properties. After historic properties were identified, the Criteria of Adverse Effect were applied to each proposed Alternative. These criteria are used to determine whether the proposed undertaking could change the characteristics that qualify the property for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Section 106 of the NHPA allows three findings for effects on historic properties:

- No Historic Properties Affected
- No Adverse Effect
- Adverse Effect

When an undertaking is found to have an adverse effect, Section 106 requires notification to the Advisory Council on Historic Preservation (ACHP) and consultation with SHPO and other interested parties regarding appropriate avoidance, minimization, or mitigation measures. Generally speaking, minimization measures might include redesigning aspects of a project to lessen the effects it has on historic properties. Mitigation may include relocating buildings or structures to move them out of the project footprint or documenting them for archival purposes. For a finding of adverse effect, the product of consultation is usually an MOA or a Programmatic Agreement (PA), per 36 C.F.R. 800.6(c), among the SHPO, federal agency, ACHP if it chooses to participate, and other consulting parties. This agreement contains stipulations specifying measures to be implemented that would avoid, minimize, or mitigate the adverse effects. For this proposed undertaking, an MOA or a PA would be drafted to resolve potential adverse effects from the proposed undertaking.

There are no known archaeological resources at the Sacramento Peak Observatory, and no archaeological survey work was conducted there as part of the Section 106 process. In addition, no traditional cultural properties (TCPs) have been identified at the Sacramento Peak Observatory. Therefore, effects to archaeological resources or TCPs are not analyzed in this technical report. An unanticipated discovery plan would be in place prior to any demolition activities associated with the selected Alternative to address archaeological resources that might be discovered during demolition.

The term mothballing is used in this technical report to refer to the process of removing a facility or structure from daily use while maintaining the general condition for a defined period and removing equipment and structures from use while keeping them in working order. The NPS guidelines for mothballing, presented in Preservation Brief 31, "Mothballing Historic Buildings," applies specifically to historic buildings instead of instruments or equipment (Park, 1993). However, since a similar approach would be used to preserve certain historic instruments and structures at the Observatory, the term mothballing is used in this technical report for historic instruments, as well as historic buildings, to indicate that they will be preserved, protected, and maintained in an operational readiness condition. Historic instruments and equipment at Sacramento Peak Observatory would be protected and preserved in accordance with *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings* (Grimmer, 2017).

SECTION 2

Identified Historic Properties

2.1 Historical Context

2.1.1 Origins of Solar Astronomy

The Sun – nothing can be of more basic importance. It is the core of our solar system, the life giver. Worshiped as divine throughout history. So basic to our existence that it merits a single-syllable name in many cultures – Ra, Sol, and by us, Sun. (Plymate, 2001)

The study of stars, including the Sun, and celestial objects has fascinated people for thousands of years. Early cultures around the world used the planets, the stars, the Sun, and the Moon to track the passage of time and measure physical movement across the earth's surface. These measurements were achieved through observations of the sky: "In the period before 1609, before Galileo introduced the astronomical telescope to our subject, astronomers were confined to the use of the naked eye, with its limited dark-adapted pupil diameter" (Hughes, 2004). The use of instruments that employed lenses or mirrors with increasingly large apertures by astronomers in the seventeenth century "enable[d] more light to be collected and concentrated into the eye pupil" and allowed for the observation of larger quantities of stars (Hughes, 2004). In 1609, Galileo's telescope—which he used to look at the Sun and stars—had an aperture of 1.5 centimeters, but by 1820, the "great Dorpat refractor" had an aperture of 24 centimeters (Hughes, 2004). This improvement of technology "led to an increase in stellar limiting magnitude and a huge change in the number of stars that could be detected" (Hughes, 2004).

During the 1660s, Isaac Newton demonstrated that a glass prism could be used to split sunlight into a spectrum of colors though the process of "refraction" (National Center for Atmospheric Research [NCAR], 2015). More than a century later, William Herschel discovered that invisible "rays" existed beyond the red end of the solar spectrum, which eventually became known as infrared radiation. A few years later, in the beginning of the nineteenth century, Johann Wilhelm Ritter observed ultraviolet radiation extending in rays from the violet end of the solar spectrum. Further developments in the understanding of the solar spectrum were made in 1802, when William Hyde Wollaston used a glass prism and observed dark lines between the chromatic divisions of the spectrum. Although at the time Wollaston did not consider this to be a great discovery, "this marked the first step towards solar spectroscopy, which was to revolutionize Solar Physics in the second half of the century" when the same dark lines were rediscovered in 1817 by Joseph von Fraunhofer (NCAR, 2015). It soon became clear that the dark lines could offer important information about the Sun's atmosphere. As a result of this discovery, "[s]till today, most information gathered on the Sun and stars is obtained through spectroscopic means" (NCAR, 2015).

Although important advances in the understanding of the solar spectrum occurred during the early nineteenth century, "telescopes which specialize in solar observations are fairly recent, dating from the late nineteenth century onwards" (Von der Luhe, 2009). In 1939, an instrument referred to as a coronagraph was invented by Bernard Lyot, a French astronomer. The invention solved the problem of observing the corona—the gaseous plasma that surrounds the Sun—despite the intensity of the Sun's brightness. A coronagraph essentially uses a large disk to block the Sun and feign an eclipse (NSO, 2015). This technology "enable[d] astronomers to observe the hot gas (the corona) surrounding the Sun without having to wait for total solar eclipses" and would become an important technology used at solar observatories around the world (Oppenheimer, 2003).

2.1.2 Origins of Sacramento Peak Observatory

"I am the proudest of the observatories that I have built in the West, not only the one at Climax and its Boulder headquarters, but also the Sacramento Peak Observatory…."

– Donald H. Menzel in 1961 (Bogdan, 2002)

The High Altitude Observatory (HAO), a solar observatory located on the Continental Divide at an elevation of over 11,000 feet in Climax, Colorado, was incorporated in April 1946. The observatory, which was associated with the Harvard College Observatory and the University of Colorado, had been previously established in 1940 by Walter Orr Roberts and Donald Menzel, an astrophysicist and Roberts' doctoral advisor. At the time, "it was the world's highest permanent astronomical observatory; and it was specifically designed for solar studies" (Bushnell, 1962). A Lyot coronagraph, the first of its kind to be available in the United States, was installed at the HAO. The Climax coronagraph was "larger than the original, portable version, with improved optics – and the first in the Western hemisphere" (Liebowitz, 2002). Roberts' role with the HAO was supposed to be limited to 1 year; however, his responsibilities at the Observatory were extended after the start of World War II. As the "sole observer" at the site during these years, Roberts worked with the Bureau of Standards, "forecasting radio conditions on the basis of solar observations" (NCAR, 2013; Bushnell, 1962). These studies of the upper atmosphere were useful in predicting conditions for radio communication, guided missiles, and supersonic aircraft (Liebowitz, 2002). As a result of this collaboration, solar observations "became essential to the war effort" (NCAR, 2013), and furthering the field of solar astronomy became an appealing goal for astronomers and military alike.

The Sacramento Peak Observatory "in New Mexico grew directly out of the earlier project for Climax, and it was conceived as a complementary enterprise, but it evolved in a very different direction" (Liebowitz, 2002). During the first years of operation of the HAO, Roberts had realized that "there were long periods of cloudiness, especially during the winter, when it was not possible to make observations" (Liebowitz, 2002). For this reason, it was decided that a second solar observatory should be established (Bushnell, 1962). In addition, the practical applications for solar research discovered by the military during World War II regarding the impact solar activity had on radio communication spurred the idea for a military-funded observatory. Thus, it became an important mission of the U.S. Air Force to establish a solar observatory: "after the war, when the Air Force recognized the need to organize its own long-range program of solar studies, it quite naturally turned for specialized assistance to the recently formed High Altitude Observatory (HAO)" (Sears, 1965–1966; Bushnell, 1962). In September 1947, the U.S. Air Force issued a contract to HAO and Harvard University to conduct a survey, identify an appropriate site for a new solar observatory, and determine which instruments to install (Bushnell, 1962).

Several requirements for the new site were defined: the climate needed to be "'out of phase' with the season at Climax" to double the amount of viable observation time and "the atmosphere above the new site should be exceptionally free from clouds or haze, dust and other contaminant" to allow for prime "seeing" capabilities (Bushnell, 1962). Roberts and Menzel used a plane to examine the White Sands Proving Ground (an area used as a research rocket firing range), Holloman Air Force Base located just east of White Sands, and Alamogordo, New Mexico. As a result of their investigations, Roberts and Menzel "concluded that the section of the Sacramento Mountains in which Sacramento Peak is located would be especially promising for a solar research site. Further inquiries and inspection tended to confirm this initial reaction" (Bushnell, 1962). In addition, a site in the vicinity of Holloman Air Force Base was appealing since the base "planned to supply the equipment to start the observatory, and maintain it after it was built" (Ramsey, 2002). Sacramento Peak had a number of advantages: an elevation of 9,253 feet that was high enough to have lower atmospheric dust levels, but low enough to be more accessible to researchers than Climax at 11,000 feet; a moderate amount of rainfall; a high percentage of sunshine; and a thick forested setting to help block movement and interference from rising air currents. These qualities indicated to researchers that "[p]otentially, in fact, Sac Peak

[Sacramento Peak Observatory] and Climax promised to make an excellent 'team' of research sites, the former being ideally suited for continuing day-to-day observations while the latter could properly emphasize 'special project' research requiring fine viewing conditions but only for limited durations" (Bushnell, 1962).

As a high school student, Colorado native Rudy Cook visited Climax and met Roberts, igniting in Cook an acute interest in solar astronomy. A few years later, Cook returned to Climax in the hope of finding a job there. Instead, Roberts and Dr. John "Jack" W. Evans, another student of Menzel's who would become the first director of Sacramento Peak Observatory, offered Cook a job helping them establish a new observatory. A small crew, including Cook, Roberts, Evans, and two others, traveled to Sacramento Peak and set up camp, at first in "an old railroad box car" (Ramsey, 2002). In 1947, they started collecting daily observations regarding the conditions of the site. Cook's companions returned home soon after their arrival, leaving Cook alone with his dog, Rocky. In December 1947, "Menzel and Roberts made a documented though still tentative recommendation that Sacramento Peak be chosen for the Air Force solar research site" (Bushnell, 1962). In April 1948, the Committee on Geophysical Sciences within the War Department's Research and Development Board formally "accepted the High Altitude's [sic] Observatory's [HAO] recommendation for Sacramento Peak" (Liebowitz, 2002). A contract was written, mandating that the Air Force "accomplish the creation of the observatory" (Liebowitz, 2002). The specifics of the contract called for the preparation of detailed plans for an integrated solar research facility, which would combine observational, analytical, and data-reduction activities, all on a larger scale than at any comparable observatory; design, development, and fabrication of the required optical device; and concurrently, theoretical studies of solar structure and characteristics (Bushnell, 1962). With this contract in place, the facility on Sacramento Peak started to take shape as a significant solar observatory and the burgeoning community of Sunspot began.

2.1.3 Development of Facilities at Sacramento Peak Observatory

"…[W]hile the Sac Peak program covers the entire sun, the research studies do concentrate on the solar chromosphere—the hot, transparent, intensely active layer extending several thousand miles immediately above the opaque solar disk, or photosphere." (Sears, 1965–1966)

Conditions on Sacramento Peak were difficult and lonely for Cook as the sole resident of the new Observatory during the fall of 1947. The environment was treacherous and the copious amounts of mud made travel up and down the mountain at times impossible. Several months after Cook's arrival, Roberts hired Lee Davis to join Cook on the peak and assist in the daily site condition observations. Soon after, Cook's wife Mae and their young daughter Karen joined the two men (Ramsey, 2002). By 1949, a "regular program of solar research had commenced at Sac Peak [Sacramento Peak Observatory]…centered around the idea of a 'routine solar patrol', with comprehensive monitoring and 'alerts to assist the forecasting of radio communications" (Liebowitz, 2002). Dr. Menzel visited the site regularly, but at this time in the Observatory's history, there were three full-time Harvard University/HAO resident observers along with their respective families: Rudy and Mae Cook, Lee and Rosemary Davis, and Harry and Joanne Ramsey. Joanne Ramsey wrote a book titled *New Mexico, Sunspot, Sacramento Peak Observatory in the Beginning* that presents the memories and narratives of the early residents of the Observatory. Ramsey describes how Cook and Davis, "together, they cleared more trees to improve visibility, for observing" (Ramsey, 2002). As illustrated by this description, the establishment of Sacramento Peak Observatory relied heavily on the innovation, drive, and courage of these first residents.

2.1.3.1 Early Buildings and Structures (Late 1940s and 1950s)

The first buildings at the Sacramento Peak Observatory were temporary and few. Cook and Davis constructed a Sears and Roebuck prefabricated steel garage in 1947 and used it, along with a 16-foot trailer. They installed a water tank in the garage and used the structure as a shop and office. The U.S. Air

Force supplied the trailer, which included a small kitchen with a working stove. Eventually, a small wood enclosure was constructed to connect the 16-foot trailer to the garage for weather protection. Neither the garage nor the 16-foot trailer remain extant. Cook kept a journal that marked a number of specific accomplishments that were made at the site during these first few weeks, including building a privy and garbage pit on August 19, 1947; building a shower on August 20; and marking the alignment of the new road to the mountain peak on August 29. During the following weeks, the residents started to bulldoze a road leading to the Observatory. Cook and Davis used a weapons carrier jeep, which lacked a roof, to drive up and down the mountain. Later in 1947, another 17-foot trailer was added to the Observatory. Both the 16-foot trailer and the 17-foot trailer were used as residences as needed over the next few years (Ramsey, 2002).

In 1948, the U.S. Air Force constructed the site's first "Jamesway," a Quonset hut-like structure used as a dormitory to house single men that were temporarily stationed at Sacramento Peak Observatory for research or construction. The "Jamesway" was 25 feet long, included a stove for heat and cooking, and was constructed using a plastic-type cloth that was insulated and rain proof (Ramsey, 2002). The structure, which is no longer extant, could accommodate 12 to 14 men during the summer months; during the rest of the year, it was occupied only by four or five men. A shower was rigged on top of the Sears and Roebuck garage and involved a "large tank balanced on railroad ties for water pressure" (Ramsey, 2002).

In 1948-1949, the first two prefabricated houses on Sacramento Peak Observatory were erected along with a workshop and a garage, none of which remain extant (Ramsey, 2002). The houses were long, rectangular plan residences clad in shingles, with a front gable roof. Construction on other infrastructure started soon after, including an electrical generating plant, installation of water and sewer lines, improvements to access, and the establishment of radio communication with Holloman Air Force Base (Bushnell, 1962). Originally, residents of the Observatory relied on water from the Sacramento River, which had to be pumped into a 300-gallon tank trailer and brought back to the Observatory. Eventually a pump and pipe line were installed to bring water to the peak. Other improvements were made to improve pedestrian access within the Observatory; residents laid "wide, long metal planks to walk on; hopefully to keep the mud out of the buildings" (Ramsey, 2002).

Several telescopes were installed during the late 1940s and early 1950s, though they were not housed in buildings and generally were covered with waterproof tarps at night. One of these early instruments was a "4 ¼ inch coronagraph mounted on an eight-foot equatorial spar. This was the nation's second successful Lyot-type coronagraph, having about the same aperture as the one at Climax but substantially more compact in design" (Bushnell, 1962).

Grain Bin Dome

In 1950, a 6-inch telescope that would eventually be used as a coronagraph was installed at the site and "was principally used for taking motion pictures of solar prominences through a birefringent filter," a mechanism that transmits light in a series of distinct wavelength bands (Bushnell, 1962; Photonics Media, 2015). That same year, plans started on a 16-inch coronagraph "which was to be the observatory's most important single item of equipment" (Bushnell, 1962). A twin solar telescope was also planned for installation in Climax, and together they would be the world's largest of their type (Bushnell, 1962). Design and construction of the instrument involved a number of people, including Bernard Lyot, who invented the coronagraph; Lyot "served as a consultant in selection and testing of the glass blanks (which were made in France) for the optical components," which were subsequently replaced in 1963 (Bushnell, 1962). A "flare-patrol system" which regularly recorded "solar flares (or sudden localized increases in the brightness of the luminous gas)" was established at Sacramento Peak Observatory in March 1951 (Bushnell, 1962). Within 5 months of operation, the instrument had recorded 252 solar flares, "sufficient in itself to make some definite contributions to the understanding of flare phenomena" (Bushnell, 1962). Holloman Air Force Base also used instruments at the

Observatory to track its missile/rocket testing missions (Bushnell, 1962). Use of Sacramento Peak Observatory for this purpose continued for several years.

The first telescope dome, or indoor instrument, was a 6-inch prominence telescope mounted on a 10-foot spar and placed within a silo that had been ordered from the Sears & Roebuck catalogue (Photo 1). A slit was cut in the roof of the silo for observation purposes. As Ramsey describes it in her 2002 narrative:

> The instruments needed protection from the weather, so a Grain Bin was ordered from Sears & Roebuck. A road was made through the woods and the bin was erected as the 'Dome.' It had a sensor which automatically rotated it toward the Sun. In the 'Dome,' was an instrument called a Solar Spar, which was a 10-[foot] lengthy metal box used to mount different telescopes. Mounted on the Spar were four telescopes. One had a prominence camera. It took pictures of the eruptions or gases on the edge of the Sun called prominences. Another telescope was used to look at white-light images of the Sun, called Sunspots. The third telescope was called the Hydrogen Alpha Flare Patrol. It had a narrow-band solar filter to see flares on the face of the Sun. The fourth telescope was the Coronagraph designed by Dr. Evans.

The Dome, which came to be known as the Grain Bin Dome, was used daily from 1951 to 1963, during which time it recorded flare patrol images. A trailer that is no longer extant was placed adjacent to the instrument and used as an office. Around the time of the Grain Bin Dome's construction, Sacramento Peak Observatory became directly associated with the U.S. Air Force's Geophysics Research Directorate at Cambridge and was named the Upper Air Research Observatory. Evans was appointed as superintendent (Bushnell, 1962). Subsequent telescopes were installed in the Grain Bin Dome in 1952, 1955, and 1957. In 1963, the construction of the Hilltop Dome made the Grain Bin Dome obsolete. A nighttime telescope was installed in the Sears & Roebuck structure in 1995. The structure is no longer in active use, though it remains a historical attraction for visitors and the residents of Sunspot (NSO, 2015).

Photo 1. Grain Bin Dome

The John W. Evans Solar Facility (formerly the Big Dome)

A new contract between the U.S. Air Force and Harvard University implemented a new contract in December 1951 that required Harvard to operate the large coronagraph that was still under construction (Bushnell, 1962). The design for this 16-inch coronagraph included a 26-foot equatorial spar. John Evans designed the optics for the instrument, while Westinghouse Electric Corporation was contracted for the instrument's construction (Liebowitz, 2002). The mechanics and optics of the instrument, which were assembled and mounted in 1951–1952, were placed in a "specially designed enclosure with a rotating turret" known as the "Big Dome" (Liebowitz, 2002). The large 30-foot conical dome sits on concrete walls (Photo 2). A rectangular plan, concrete block laboratory wing extends from the domed structure to the east. A small, shed-like "slide-off" building that moves on raised tracks extends from the south elevation and remains extant. After its construction, the instrument within the Big Dome was "repeatedly modified, rearranged, and added to" (Bushnell, 1962). Some changes also occurred to the exterior building structure. Circa 1961, a new laboratory wing was added to the west side of the domed structure, the mirror image of the original east wing (Air Force Missile Development Center, 1961). Two years later, circa 1963, a larger rectangular plan addition was added onto the west addition (circa 1961) (PHM, 1963).

On August 18, 1987, the Big Dome was rededicated as the John W. Evans Solar Facility. The facility's commemorative in situ plaque reads: "The John W. Evans Solar Facility: Named in honor of the first Director (1952–1975) of Sacramento Peak Observatory, who transformed a remote mountain-top observatory into a world-renowned center for solar astronomy" (1987). The John W. Evans Solar Facility was used regularly for experiments and observations starting in 1954. Currently, the facility is not in active use.

Photo 2. The John W. Evans Solar Facility (formerly the Big Dome)

Willard Carl Kruger

Willard C. Kruger is the architect who designed many of the buildings constructed during the 1950s at Sacramento Peak Observatory. Prior to his work at the Observatory, Kruger had gained some notice for his work throughout New Mexico. During the 1930s, Kruger served as the head of the New Mexico Works Progress Administration (WPA) Architectural Department. Eight of his designs in New Mexico are listed in the NRHP, including the Pueblo Revival-style Clayton Public Library and several projects in the Clayton Public Schools Historic District in Clayton; the Columbian School, Longfellow School, and Raton Junior-Senior High School in Raton; Las Vegas Municipal Building in Las Vegas; the Tierra Amarilla AFS P-8 Historic District in Tierra Amarilla; and the Carrie Tingley Hospital for Crippled Children in Truth or Consequences (Monroe, 2002). Kruger is remembered as a "prominent architect in Santa Fe…best known for designing and developing the city of Los Alamos along with designing the laboratories that housed the development of the Atomic Bomb, also known as the Manhattan Project, during World War II" (New Mexico USA Obituaries, 2016). In addition to these accomplishments, Kruger also designed the New Mexico State Capital (1966), as well as many other state, federal, commercial projects and university buildings during his 50-year career (New Mexico USA Obituaries, 2016). Kruger died in 1984.

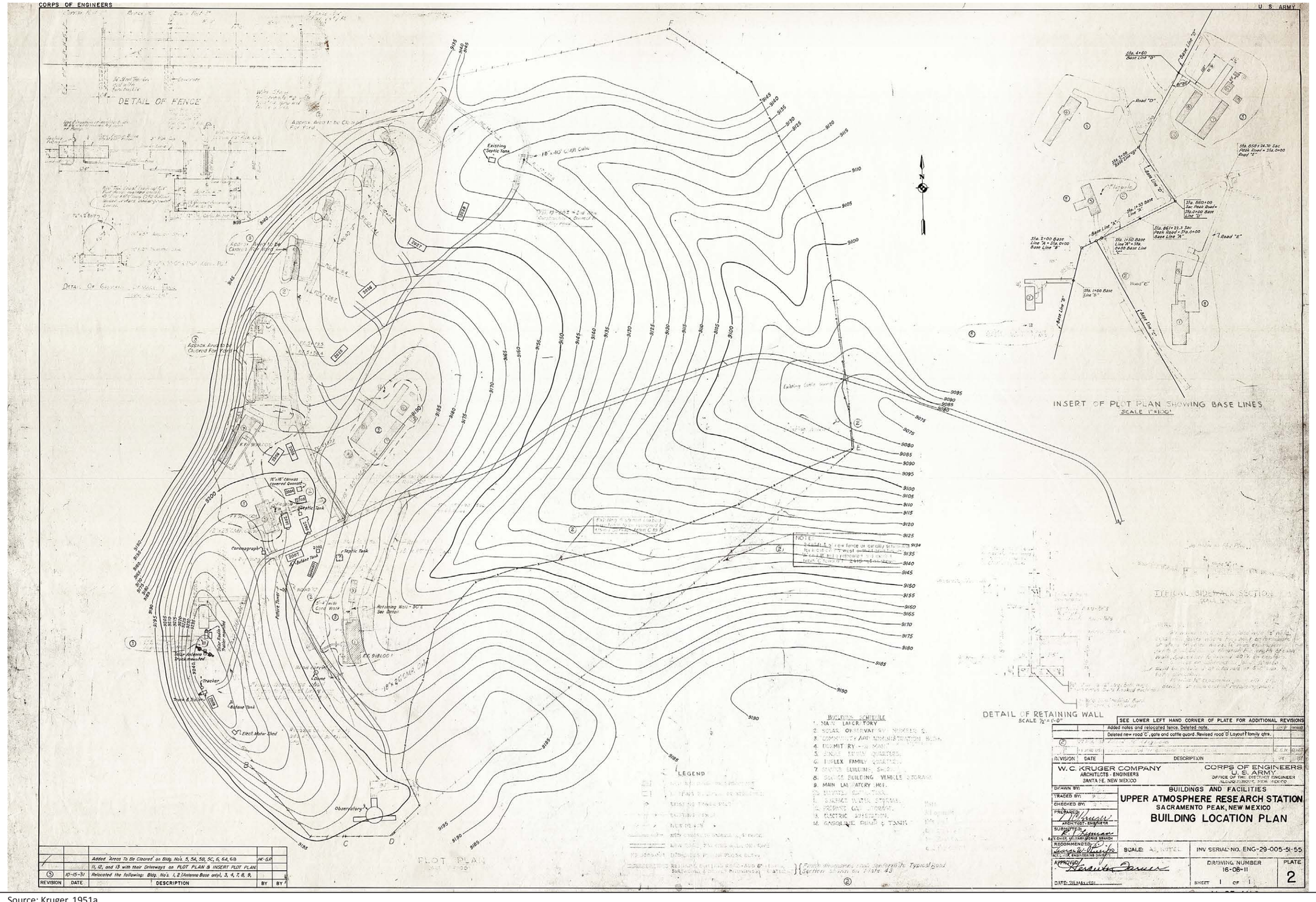
A building location plan for the Upper Air Research Observatory (the plan's title block has the Observatory's name incorrectly as the Upper Atmosphere Research Station), dated 1951 and signed by W.C. Kruger, shows 17 buildings and structures that were already in place, generally numbered with building numbers that are no longer used (Kruger, 1951a). The plan shows several more Quonset huts that were constructed in 1951 to serve various purposes, including offices, laboratories, dormitories, a kitchen, recreation space, and a library. The functions of the Quonset huts changed depending on the need at the time. The 1951 Quonset huts had metal frames and were clad in corrugated metal sheets. A total of 10 of the buildings shown as existing on the 1951 plan have been demolished; 7 remain extant. The buildings shown as existing in 1951 are listed in Table 1.

Several instruments that were not housed in buildings were also shown on the 1951 site plan, including the coronagraph located just south of the proposed Community Center and a truck-mounted solar antenna and two trailer-mounted solar radio instruments located just south of the proposed Hilltop

Laboratory. Other miscellaneous facilities are shown as existing on the 1951 site plan, including several butane tanks, septic tanks, and an electrical motor shed (Figure 3).

Table 1. Facilities Shown as Existing on the 1951 Building Location Plan

1951 Name	Current Name, Building Number	Extant?
Dome	Grain Bin Dome, Building 3002	Extant
Building 2026	Furniture Storage, Quonset Hut, Building 3029	Extant
Building 2005	Storage, Quonset Hut, Building 3011	Extant
Building 2006	Storage, Quonset Hut, Building 3012	Extant
Building 2007	Storage, Quonset Hut, Building 3008	Extant
Observatory	John W. Evans Solar Facility, Building 3000	Extant
A 16-foot by 16-foot Canvas Covered Quonset Hut	N/A	No longer extant
Building 2028	N/A	No longer extant
Building 2027	N/A	No longer extant
Building 2025	N/A	No longer extant
Building 2003	N/A	No longer extant
Building 2004	N/A	No longer extant
Building 2001	N/A	No longer extant
Building 2000	N/A	No longer extant
Building labeled “Quonset” just southeast of Building 2007	N/A	No longer extant
Building 2002	N/A	No longer extant
Building 2008	N/A	No longer extant



Source: Kruger, 1951a.

FIGURE 3
1951 Building Location Plan, W.C. Kruger
Sacramento Peak Observatory
Sunspot, New Mexico

EN0310151054SAC

Between 1951 and 1952, the Observatory's built environment continued to expand. "By the end of August 1952 the original Sacramento Peak [Observatory] building program was substantially finished, with a total of 28 buildings accepted, not to mention cattle guards and utility lines" (Bushnell, 1962). Sacramento Peak Observatory, which was known at the time as the Upper Air Research Observatory, had been established as "the Air Force's leading center of solar studies" (Bushnell, 1962). According to a history of the early years of the Observatory titled *Donald Menzel and the Creation of the Sacramento Peak Observatory* by Ruth Prelowski Liebowitz, Dr. Marcus O'Day, who worked for the U.S. Air Force and collaborated with Menzel on the founding of Sacramento Peak Observatory, "wanted quality designs for the buildings, and he hired the architect Walter Gropius as a consultant" (Liebowitz, 2002). Gropius was a famous German architect that founded the Bauhaus School of architecture; however, it is unclear how involved Gropius was in the designs at Sacramento Peak Observatory, as no building plans for the project attributed to Gropius have been discovered (Bushnell, 1962).

Included among the 1952 building program were 10 Redwood Family Housing units – ranch-style houses, "well-built, permanent-type family quarters set along the rim of the mountain and looking out upon a scenic panorama of breathtaking proportions" (Bushnell, 1962) (Photo 3). Archival drawings for the Redwood Family Housing are signed by Kruger with W.C. Kruger Company, Architects and Engineers of Santa Fe, New Mexico (Kruger, 1951b). The 1951 Building Location Plan shows numerous proposed building locations, including the seven Redwood Family Housing units that would be constructed in 1952 – three duplex family quarters and four single family quarters. In addition, 12 other proposed facilities are shown such as the Community Center and the Main Lab, which were also constructed in 1952 (Figure 3). For the primary proposed buildings and structures, Kruger provided architectural plans, elevations, sections, and details, as well as plans and details for heating, plumbing, and electrical systems. The Community Center was constructed in the location of one of the original prefabricated houses; as a result, the house was relocated "over across from the meadow Quonsets" (Ramsey, 2002). The proposed facilities are listed in Table 2.

Photo 3. Building 3014, Redwood Family Housing Duplex

Table 2. Facilities Shown as Proposed on the 1951 Building Location Plan

1951 Name	Current Name, Building Number	Year Constructed
Main Laboratory	Main Lab, Building 3004	1952
Solar Observatory Number 2	Hilltop Dome, Building 3040	1963
Community and Administration Building	Community Center, Building 3010	1952
Dormitory	Visitor Officer's Quarters, Building 3013	1952
Single Family Quarters	Redwood Family Housing, Single Units	1952
Duplex Family Quarters	Redwood Family Housing, Duplex Units	1952
Service Building Shops	Civil Engineering (CE) Shop, Building 3032	1953
Service Building Vehicle Storage	CE Shop, Building 3031	1953
Main Laboratory Shop	Machine and Electronics Shop, Building 3005	1953
Elevated Water Tank	Water Tower	1952
Surface Water Storage	Pump Station Reservoir, Building 3033	1953
Propane Gas Storage	Propane Storage	Early 1950s
Electric Substation	Power System – Substation	Early 1950s
Gasoline Pump and Tank	Fuel Storage	Early 1950s

The 1951 Building Location Plan indicates the proposed landscape features in the vicinity of several proposed facilities. For example, surrounding the Main Laboratory building, the site plan indicates an approximately 50-foot-long retaining wall and a 4 to 5-foot-wide concrete sidewalk. A flagpole is proposed outside the Community Center. Small areas along the western edge of the Redwood Family Housing are labeled as the approximate areas to be cleared for yards. Several roads are also proposed to connect the various facilities and residences (Kruger, 1951a). Most of the buildings proposed by Kruger on the 1951 plan were constructed between 1952 and 1953. The Hilltop Laboratory (identified on the plan as Solar Observatory Number 2), however, was not completed until 1963 and is described later in this historical context. It appears that most of the design elements shown on the original drawings for the Hilltop Laboratory were executed when the building was subsequently constructed. However, certain aspects of the current Hilltop Dome building do not match these original drawings, such as some of the front elevation fenestration, indicating the designs were updated prior to construction (Kruger, 1951c).

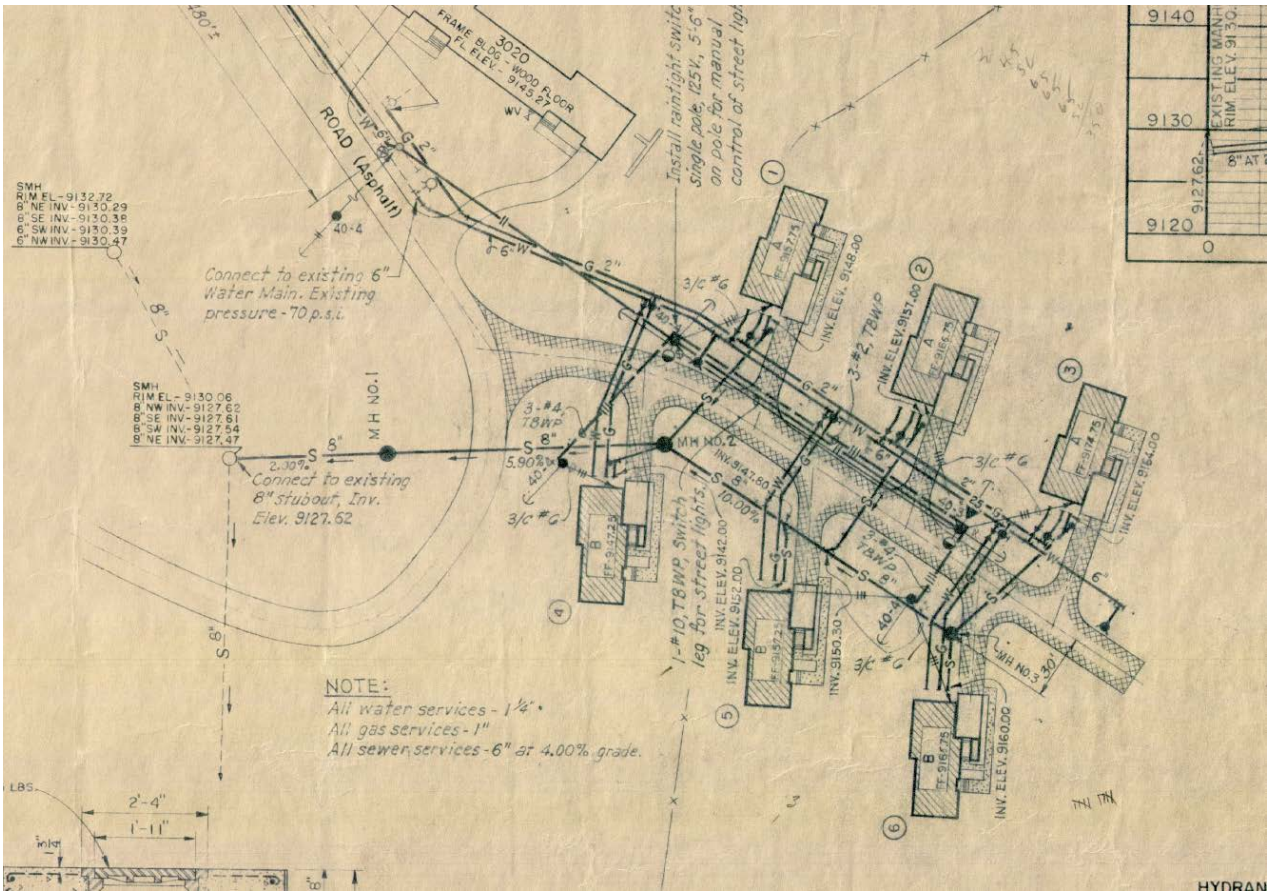
The Observatory became slightly more accessible to researchers in 1955, when the helicopter landing area was constructed:

> The peak's isolation was diminished in still another way during 1955, with the construction of a helicopter landing strip. This fulfilled a requirement for helicopter service to Sac Peak [the Observatory] which GRD [Geophysics Research Directorate] had underscored as far back as May 1951 and provided much faster access to the installation from Holloman Air Force Base both as a matter of convenience and as a safety measure

in case of snowstorms that might block road travel (or other possible emergencies). (Bushnell, 1962)

On May 1, 1956, the name of the facility was officially changed to “Sacramento Peak Observatory.” The population of the Observatory continued to increase; however, there was not enough housing to accommodate all the residents. The original Quonset huts and Redwood Family Housing units were at capacity. In response to this housing shortage, funding was provided in 1957 to construct six more Redwood Family Housing units on a hill at the northern most point of the facility, an area that became known as Hound Dog Hill. These residences were finished in 1958 (Bushnell, 1962) (Photo 4). Drawings for the residences on Hound Dog Hill were also done by W.C. Kruger, this time with W.C. Kruger and Associates. Plot plans for the six buildings show the proposed layout of Hound Dog Hill, including proposed sidewalk details, street lighting units, and a road extension connecting to the main Observatory road (Figure 4) (Kruger, 1957).

Photo 4. Building 3045, Redwood Family Housing on Hound Dog Hill



Source: W.C. Kruger, 1957; revised 1959

Figure 4. Close-up of Hound Dog Hill Layout

2.1.3.2 Continued Development at Sacramento Peak Observatory (1960s)

Patrol Dome and Hilltop Facility

The patrol instruments were among the earliest installed at Sacramento Peak Observatory. Starting in 1957, however, the original patrol instruments were "replaced by completely new instruments especially designed and built at the Observatory. These instruments brought an appreciable increase in both quantity and quality of routine coronal spectra" (Bushnell, 1962). Numerous patrol instruments were in operation during the early 1960s. A history of the site that was written in 1962 by David Bushnell states that similar to the other instruments at Sacramento Peak Observatory, "all of the present patrol instruments have, of course, undergone repeated modification and improvement since they began operation. In 1960, construction started on a small domed enclosure that would become known as the Patrol Dome, located at the site's highest elevation in the southwest section of the observatory" (Bushnell, 1962). According to Bushnell, several patrol instruments were moved into the Patrol Dome along with new instrumentation that doubled the capacity at the Observatory for such observations (Bushnell, 1962).

The Patrol Dome, which took several years to become fully operational and remains extant, is a 20-foot dome on concrete walls. The dome contains sliding doors that open to allow for observations. The dome also rotates to follow the Sun and take patrol images. In 1963, the Hilltop Laboratory, a modern, rectangular plan, concrete block building, was constructed just north of the Patrol Dome. A concrete block, enclosed corridor was subsequently added to connect the Hilltop Laboratory building to the Patrol Dome, at which point the facility became known as the Hilltop Dome and essentially replaced the Grain Bin Dome (Photo 5). Historically, the "Hilltop Dome contain[ed] several telescopes that [had] one

task only: to look at the whole Sun all the time that the Sun [was] visible" (*Mountain Times*, n.d.). The instrument was used to take "pictures of the entire sun at regular intervals…during clear daylight hours and thus to record automatically any except the very briefest of solar flares" (Bushnell, 1962). In 1974, the first Solar Observing Optical Network (SOON) was installed at the Hilltop Dome that worked with three other telescopes around the world to monitor solar activity. This instrument was later replaced in 2002 with the Improved Solar Observing Optical Network (ISOON) instrument, the objective of which was "to improve solar monitoring capabilities and to reduce operating costs via less required maintenance (design simplification compared to SOON) and the ability to analyze data from all ISOON sites at one central location" (NSO, 2011). Circa 2013, the ISOON telescope was moved to Kirtland Air Force Base (NSO, 2013). Currently, the Hilltop Dome is no longer used for solar observation; instead, it is used as an instrumentation and optical design laboratory for the DKIST, the large solar telescope currently under construction in Hawai'i (NSO, 2015).

Photo 5. The Hilltop Laboratory (right) with the Patrol Dome (left), connected by a corridor addition

Carl Koch

In 1960, the road leading up the mountain to the Observatory was paved, providing easier access to the site (Bushnell, 1962). By the mid-1960s, there were approximately 140 residents at Sacramento Peak Observatory, 70 of whom were Observatory personnel, including 10 military personnel, 28 civil service personnel, and 32 contractor personnel (Bushnell, 1962; NCAR, 1965–1966). Because of the remote location of Sacramento Peak Observatory, employees generally lived on site with their spouses and many people raised children at the Observatory.

To accommodate the growing numbers of families, 21 Relocatable Housing units were installed along the northeastern edge of the Observatory (Photo 6). The buildings were designed for the U.S. Air Force by Carl Koch of Carl Koch and Associates, Inc. *Progressive Architecture* magazine described Koch, a Harvard-trained architect, as the "grandfather of prefab" for his work as a "champion of low-cost housing who designed prefabricated homes and developed the Techcrete system" (Long, 1998). Using

this new system, Koch founded the Techbuilt Company, which manufactured Techbuilt houses. This was a "low-cost, semi-factory-built modern style house, which used modular construction" (The Techbuilt Renovation, 2015). The designs for these structurally innovative houses were "based on a consistent four-foot wide module for all major building components such as wall, floor, and roof panels. The pieces were delivered by truck and could be erected in a few days" (The Techbuilt Renovation, 2015). Although Techbuilt Houses relied on a system of standardized panels, the "variation in the type and placement of panels allowed for a variety of design while still keeping costs down" (Instant House, 2012). Prior to 1963, more than 3,000 Techbuilt Houses were sold in the United States (North Carolina Modernist Houses, 2017). Most Techbuilt Houses were characterized by simple shapes, gabled roofs, overhanging eaves, and large glass expanses on the gable-end exterior walls.

The drawings for the one-story Relocatable Housing units at Sacramento Peak Observatory are dated 1962 and incorporate several of the basic design characteristics for which Koch was known in his Techbuilt Houses, including the simple shape, gabled roof, and overhanging eaves (Koch, 1962). The one-story, ranch-style houses are simple, utilitarian designs which are all nearly identical. Their most noteworthy characteristic is their "relocatable" quality, which results from the fact that they are foldable – with hinged walls that accordion in towards the central axis of the house. Utilities for these houses, including all piping, was located down the center of the house, enclosed in the central hallway under the gable peak. Thus, the walls could be folded in and the houses could be stacked and transported on the back of a truck. Once installed at their current location in 1966, however, the Relocatable Housing units at Sacramento Peak Observatory were never moved.

Photo 6. Relocatable Housing

The firm of Flatow-Moore-Bryan-Fairburn completed the site work around the Relocatable Housing, including roadwork, grading, and siting. Drawings for the site work are dated 1963 and 1964. Other construction occurred at the Observatory during the mid-1960s. An addition was added to the John W. Evans Solar Facility and a large two-story addition was constructed, extending from the east elevation of the Main Lab (Bushnell, 1962).

Richard B. Dunn Solar Telescope (DST), formerly Vacuum Tower Telescope

The architect/engineer Charles W. Jones started designs for a Solar Vacuum Tower Telescope in 1963, although construction on the instrument, which was supervised by the U.S. Army Corps of Engineers, did

not start until 1966. Over the next 4 years, construction continued on what would become known as the DST, costing more than $3 million. The architectural firm of Roghlin and Baran, Associates worked on the project. An article written by Richard B. Dunn, for whom the instrument was dedicated, about the completion of the instrument was published in *Sky and Telescope* magazine in 1969, the year of its completion. The article explains:

> In our design we wanted most of all to eliminate problems of local seeing, which are discussed at every meeting on solar instrumentation. Solar astronomers worry about turbulence caused by the slot in the observatory dome, heating of the dome surfaces, heating of the telescope, local convection, and turbulence within the optical system…In our case, the dome was eliminated. We put a window high up on a 135-foot pyramidal tower and then evacuated the air from the entire telescope inside the tower. The latter reduces the effects of local convection and the vacuum eliminates the internal turbulence and seeing problems. Also, it provides the comfort of a heated observing room….” (Dunn, 1969)

The structure is sometimes compared to an iceberg since more than half of it is underground; the DST extends 136 feet above ground and approximately 220 feet below ground (Photo 7). The vertical vacuum tube is enclosed within a concrete tower with 3-foot-thick walls. At the top of the tower, there is an entrance window and two mirrors that deflect sunlight down the vacuum tube where it is reflected off the primary mirror, which has a diameter of 64 inches. From there the primary mirror “focuses the light and sends it back up to ground level, where it exits the vacuum tube and can be guided into the scientists’ experiments on optical benches” (NSO, 2015). The interior vacuum tube weighs more than 200 tons and is suspended by a bearing that contains 8 to 10 metric tons of mercury, allowing it to be fully rotational. A rectangular plan, concrete block lab building extends from the north side of the tower. The tower telescope was originally dedicated on October 15, 1969. On September 30, 1998, the instrument was rededicated to Richard B. Dunn as the DST. An in situ plaque at the facility reads:

> Named in honor of one of solar astronomy’s most creative instrument builders, this vacuum tower telescope is the masterpiece of [Richard B. Dunn’s] long scientific career at Sacramento Peak [Observatory]” (1998). Construction of the vacuum tower used for the DST significantly impacted future solar instruments: “So sharp were the images formed from this type of solar telescope, that almost every large solar telescope built since then has been based on the vacuum tower concept. (Plymate, 2001)

From 1975 to 1976, Richard B. Dunn briefly served as the director of Sacramento Peak Observatory, replacing Evans. In 1976, via an MOA with the USFS in 1950, the U.S. Air Force transferred Sacramento Peak Observatory to NSF. That same year, Jack B. Zirker was appointed as the new director of the facility (Bushnell, 1962).

Photo 7. The DST (formerly Vacuum Tower Telescope)

2.1.4 Landscape Elements of the NRHP-Eligible Sacramento Peak Observatory Historic District

The NRHP-eligible Sacramento Peak Observatory Historic District includes the main developed Observatory area; the Sewage Treatment Plant and associated water wells, as well as the section of Sunspot Highway that connects this area to the main Observatory; and the remains of the helicopter landing area northwest of the Observatory. There are 63 architectural resources that contribute to the Sacramento Peak Observatory Historic District. The contributing resources are a collection of Cold War-era buildings and structures primarily constructed between 1950 and 1969. The contributing resources have been documented on HCPI Base Forms that were submitted to the New Mexico SHPO via the New Mexico Cultural Resources Information System.

In addition to its primary contributing buildings and structures, the historic district includes numerous features and historic archaeological resources that are considered part of the historic district's setting. These features are visual elements that help contextualize the site's historical narrative. They include features such as the recreation court, roads, sidewalks, and the former helicopter landing area. In addition, building foundations remain for some of the original Quonset huts and prefabricated buildings that were constructed in or before 1951 and were subsequently demolished.

The Sacramento Peak Observatory is located within a predominantly undeveloped, forested area. The natural landscape is visually dominant, with tall trees creating a verdant backdrop to the Sacramento Peak Observatory. The elevation of the area provides for unobstructed views of the surrounding mountain scape while the steeply sloping and varied topography within the Observatory emphasizes the untamed natural setting. The buildings and structures are generally arranged within the natural setting based on their function: residential buildings (Redwood Family Housing, Redwood Family Housing on Hound Dog Hill, and Relocatable Housing) are arranged in a crescent along the northern edge of the property; the primary telescopes are located along the southwestern edge of the property; and the

administrative and operations buildings, including the maintenance area, are clustered in the center of the Observatory.

2.1.4.1 Roads, Walkways, Stairs, and Walls

The Sacramento Peak Observatory's primary road, Coronal Loop (parts of which are called Telescope Loop), is an extension of Sunspot Highway that makes a figure 8 shape within the Observatory, linking the residential area in the north to the telescope and operational facilities in the south. Several smaller, unnamed roads access various areas within the Observatory, including the maintenance area just north of the elevated water tank. In addition, paved walkways provide pedestrian access between individual buildings, as well as between buildings and Coronal Loop. In addition to walkways, the hilly terrain at the Observatory contains outdoor stairwells to facilitate pedestrian access in steeply sloped areas of the site. Retaining walls and decorative stone walls are other elements of the historic district that serve functional and aesthetic purposes. Photos 8 through 11 show the Observatory's roads, walls, and stairways.

Photo 8. Coronal Loop with the Main Lab and Water Tank in the distance

Photo 9. Community Center's stone wall

Photo 10. Stone wall adjacent to the John W. Evans Solar Facility

Photo 11. Outdoor stairwell near the DST

2.1.4.2 Historic Archaeological Resources: Building Foundations and Helicopter Landing Area

East of the Redwood Family Housing are several rectangular building foundations. These are likely the locations of several of the Quonset huts that were identified on Kruger's 1951 Building Location Plan. Directly south of the Observatory's recreation court are the remains of the foundation for the structure identified on the 1951 plan as Building 2028 (Photo 12). Further south, the foundations for Buildings 2027 and 2025 (both demolished) also appear to remain. The remains of a building foundation have also been observed adjacent to the Community Center. It is likely that these foundations are associated with one of the original prefabricated residences, which was relocated for the construction of the Community Center and subsequently demolished.

Photo 12. Red circle identifies the location of former Building 2028's foundation, just south of the recreation court

Northwest of the Observatory's residential area are the remains of the helicopter landing area, which was constructed in 1955. The area is a long strip of cleared land that is covered with grass and surrounded by dense trees. No pavement or architectural resources remain extant. Photo 13 shows the former helicopter landing area.

Photo 13. Remains of the helicopter landing area

2.1.5 Other Observatories in the Area

Sacramento Peak Observatory was the first of several observatories established in New Mexico during the second half of the twentieth century, which led to the region emerging as a hub for astronomical research. In 1962, the U.S. Air Force established the Cloudcroft Electro-Optical Research Facility, more commonly referred to as Cloudcroft Observatory, which was located just 20 miles north of Sacramento Peak Observatory. The observatory was situated in the Lincoln National Forest and was closed in 1982

(Henry and Sherlin, 1983). New Mexico State University (NMSU) opened the Blue Mesa Observatory in 1967, located just northwest of Las Cruces, near Socorro, New Mexico. The observatory was used by students, faculty, and visitors until 1991, when the Federal Aviation Administration acquired the property and demolished the observatory (NMSU, 2014a). Apache Point Observatory, which is located less than a mile south of Sacramento Peak Observatory, was established by the Astrophysical Research Consortium (ARC) in 1985. NMSU's Astronomy Department currently operates Apache Point Observatory for the ARC. The observatory's location was chosen because "it has excellent seeing…and is close to support facilities, an airport and NMSU" (Peterson, n.d.). Apache Point Observatory currently houses the 3.5-meter Telescope, the 2.5-meter Sloan Digital Sky Survey Telescope, the 0.5-meter Small Aperture Telescope, and NMSU's 1.0-meter Telescope (NMSU, 2014b). NMSU also has the Campus Observatory in Albuquerque, the Tombough Observatory in Las Cruces, and a 24-inch reflector on Tortugas Mountain just east of NMSU's campus (NMSU, 2014b). The Karl G. Jansky Very Large Array (VLA), which was constructed between 1972 and 1980, is located in Socorro, New Mexico, approximately 140 miles northwest of Sacramento Peak Observatory. The VLA consists of 27 radio telescopes that collect data as a unit, functioning as a much larger instrument. The Long Wavelength Array is also located in Socorro. Completed circa 2011, the instrument is a multipurpose radio telescope that covers a collecting area with an approximately 400-kilometer diameter containing approximately 13,000 antennae (Ellingson et al., 2009). With these observatories in such close proximity, Sacramento Peak Observatory holds a position within a regional network of significant astronomical research facilities.

2.2 Architectural Resources

The results of the intensive architectural survey were documented in a technical report titled *Cultural Resources Evaluation, National Solar Observatory (Sacramento Peak Observatory), Sunspot, New Mexico* (CH2M, 2016) and are summarized below.

The search in the National Register Information System showed that there are no structures or buildings located within the Sacramento Peak Observatory that are listed in the NRHP. In addition, none of the buildings or structures at the Sacramento Peak Observatory had been previously evaluated for listing in the NRHP. An environmental assessment conducted in 1995 noted that "the Sacramento Peak Solar Observatory is an historic scientific compound begun in 1947, however, the buildings have not been evaluated for historical significance" (Cartwright, 1995).

In 2015, NSF determined the Sacramento Peak Observatory is eligible for listing in the NRHP as a historic district for representing an important time in science and military history and for its significant contribution to the advancement of solar astronomy (Criterion A). SHPO concurred with NSF's determination of eligibility on May 18, 2017. The Sacramento Peak Observatory is a collection of Cold War-era buildings and structures primarily constructed between 1950 and 1969 that reflects the early history of solar astronomy in the United States. The telescopes and associated facilities have influenced other, more modern solar telescopes, and the observations have greatly expanded the understanding of the Sun. There are 63 built environment resources that are contributing elements to the Sacramento Peak Observatory historic district. Additionally, NSF determined that there are two contributing telescopes on the property that are individually eligible for listing in the NRHP: the John W. Evans Solar Facility and DST. Both are eligible under Criterion A for important associations with events that have made a significant contribution to the field of solar astronomy. DST is also eligible under Criterion C for design and engineering. Both telescopes have undergone minor additions and alterations. However, these changes have not diminished the overall integrity of the telescopes.

Figure 2 and Table 3 list the properties at the Sacramento Peak Observatory that were identified as eligible for the NRHP. Information regarding contributing and non-contributing buildings to the NRHP-eligible historic district is provided in Appendix A.

Table 3. NRHP-eligible Architectural Resources within the APE

Resource Name (Year Constructed)	Description/Significance	NRHP Eligibility Determination
Sacramento Peak Observatory Historic District (1950–1969)	Collection of solar telescopes, residential buildings, administrative buildings, and site infrastructure facilities associated with NSO and the Sacramento Peak Observatory.	Eligible (Historic District); 63 contributing elements, which includes the two individually eligible telescopes listed in this table) (see Appendix A)
John W. Evans Solar Facility, Building 3000 (1952) (housed in the Big Dome)	Dome contains two coronagraphs, the largest in the United States, and a coelostat. Consists of a 30-foot dome on concrete walls.	Contributing resource to the Sacramento Peak Observatory Historic District and also individually eligible
DST (formerly Vacuum Tower Telescope), Building 3042 (1969)	A solar telescope composed of a vacuum tube centered within a concrete tower that extends 136 feet aboveground and 220 feet below the ground surface.	Contributing resource to the Sacramento Peak Observatory Historic District and also individually eligible

2.3 Archaeological Resources

Previous environmental reviews and archaeological surveys have been conducted at the Sacramento Peak Observatory. During the 1990s, a series of surveys were conducted in preparation for the construction of the Sacramento Peak Observatory Visitor and Education Center (1992 and 1995) and before planned construction of roads and buildings at the Sacramento Peak Observatory (1994 to 1995). This included an intensive archaeological survey in 1994. The associated report indicated that no prehistoric or historic archaeological sites were identified (Shields, 1995). Therefore, there are no previously identified archaeological resources at the Sacramento Peak Observatory that are eligible for or listed in the NRHP. Several historic-era archaeological resources are located within the Sacramento Peak Observatory Historic District, including the remains of the helicopter landing area and several building foundations. These were not evaluated for the NRHP as part of the cultural resources survey for the current undertaking but are located within the NRHP-eligible historic district boundaries. At this time, there are no known archaeological resources present at the Sacramento Peak Observatory that are considered historic properties under Section 106 of the NHPA.

No additional archaeological survey work was conducted at Sacramento Peak Observatory as part of the Section 106 process for this undertaking. During a conference call on February 15, 2017, and confirmed in a follow-up summary letter from SHPO dated March 1, 2017, SHPO concurred that no further archaeological surveys would be required for this undertaking.

NSF initiated Section 106 consultation with five federally recognized tribes: Hopi Tribe, Pueblo of Zuni, Mescalero-Apache, Fort McDowell Yavapai Nation, and Kiowa Tribe. In addition to letters, NSF followed up with the tribes via telephone and email. The Hopi Tribe indicated “no historic properties significant to the Hopi Tribe affected.” The Pueblo of Zuni had no concerns and asked to be added to the project contact list. No responses were received from the other three tribes, and no TCPs have been identified.

Since no known NRHP-eligible archaeological sites or known TCPs are present, effects to archaeological sites or TCPs are not analyzed further in this technical report. However, an unanticipated discovery plan would be in place prior to demolition to address any archaeological resources that might be discovered during demolition. If previously unidentified archaeological resources were discovered during demolition, ground-disturbing activities would halt in the vicinity of the find and NSF would consult with the SHPO and other Consulting Parties as appropriate regarding eligibility for listing in the NRHP, project effects, necessary mitigation, or other treatment measures, as outlined in the unanticipated discovery plan. Additional archaeological investigations could be conducted if substantial ground disturbance is required or if work is performed in areas that are currently undisturbed.

SECTION 3

Assessment of Effects

NSF is evaluating four Action Alternatives and a No-Action Alternative as part of its National Environmental Policy Act review. This section describes potential effects to historic properties under Section 106 as a result of the undertaking for each of the alternatives under consideration. No archaeological resources or TCPs are present within the APE; therefore, archaeological resources and TCPs are not included in the assessment of effects discussion.

3.1 Alternative 1 – Continued Science and Education-focused Operations by Interested Parties with Reduced NSF Funding

3.1.1 Implementation

Alternative 1 involves the potential demolition of facilities at the Sacramento Peak Observatory that contribute to the NRHP-eligible historic district; therefore, Alternative 1 could result in adverse effects under Section 106. Table 4 lists the proposed activities that could impact historic properties under Alternative 1. Any historic property not listed in Table 4 would be kept and maintained.

Table 4. Alternative 1 – Description of Proposed Activities

Historic/NRHP-eligible Historic District Properties to be Mothballed	John W. Evans Solar Facility Grain Bin Dome Storage 3037
Historic /NRHP-eligible Historic District Properties to be Demolished	Relocatable Housing (21 buildings, including the Recreation House)

A total of 21 buildings that contribute to the NRHP-eligible historic district could be demolished under Alternative 1. The removal of NRHP-eligible buildings or contributing resources to a NRHP-eligible historic district would result in an adverse effect under Section 106.

Three properties that contribute to the NRHP-eligible historic district would be mothballed under Alternative 1; Storage Building 3024 would also be mothballed under Alternative 1, but it is not a historic property. Mothballing involves removing a building from daily use while maintaining the general condition for a defined period of time. A similar process applies to preserving structures or instruments, protecting and maintaining them in operational readiness condition. Preparing historic properties for mothballing could involve securing buildings and their associated components, turning off utilities, weatherizing, and providing adequate ventilation. These steps could involve some building treatments that would affect the historic properties, but these effects would not be adverse. Modifications to buildings required during mothballing would be compatible with the historic property's style and materials, and would be executed in accordance with the NPS Preservation Brief 31, "Mothballing Historic Buildings" (Park, 1993). Instruments and equipment would be preserved in accordance with *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings* (Grimmer, 2017). If historic properties were returned to use at a future date, alterations performed as part of the mothballing process could be reversed without physical harm to the historic properties.

Although 21 contributing buildings could be demolished, Alternative 1 would retain the two individually NRHP-eligible telescopes located within the Sacramento Peak Observatory. In addition, Alternative 1 would retain 42 historic properties that contribute to the NRHP-eligible historic district, preserving a unique historical moment in the field of solar astronomy. More than half of the contributing resources would remain extant, including the historic district's primary instruments – the John W. Evans Solar Facility and DST; although the setting, feeling, and association would be altered, it would not be sufficient to render the district ineligible for the NRHP, and the historic district would retain sufficient integrity to convey its historic significance under Criterion A. Of the four proposed Alternatives, Alternative 1 would result in the least effects to historic properties compared to Alternatives 2, 3, and 4.

3.1.2 Operations

Under Alternative 1, operations would continue with an interested party. Three historic properties would be mothballed: the John W. Evans Solar Facility, the Grain Bin Dome, and Storage 3037. The John W. Evans Solar Facility, which is individually eligible for the NRHP under Criterion A, and the Grain Bin Dome are not in active use; therefore, mothballing would not alter the existing operations of the instruments or the historic district. Although they would not be used for observations or research, the equipment and structures would be protected, maintained, and kept in working order. Mothballing of historic instruments and equipment would follow guidance in *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* (Grimmer, 2017). Mothballing the instruments could result in a beneficial effect by maintaining them for future use instead of leaving them abandoned. Storage 3037 is a small concrete storage facility; mothballing the building would have a negligible effect on the operations of the historic district. Mothballing of Storage 3037 would be planned and completed in accordance with the NPS Preservation Brief 31, "Mothballing Historic Buildings" (Park, 1993). Therefore, operating the facility under Alternative 1 after the demolitions have been completed and while three historic properties are maintained through mothballing would not alter the characteristics of the remaining Sacramento Peak Observatory historic properties that qualify them as eligible for the NRHP and would result in no further adverse effects under Section 106 beyond that incurred under implementation of the alternative described in Section 3.1.1.

3.1.3 Summary of Alternative 1

Alternative 1 involves the potential demolition of historic properties that contribute to the NRHP-eligible historic district. As a result, the overall finding of effect for the Alternative is an adverse effect to historic properties.

3.2 Alternative 2 – Transition to Partial Operations by Interested Parties with Reduced NSF Funding

3.2.1 Implementation

Similar to Alternative 1, Alternative 2 involves the potential demolition of facilities at the Sacramento Peak Observatory that contribute to the NRHP-eligible historic district; therefore, Alternative 2 would result in adverse effects under Section 106. Table 5 lists the proposed activities that could affect historic properties under Alternative 2. Any historic property not listed in Table 5 would be kept in active use and maintained.

Table 5. Alternative 2 – Description of Proposed Activities

Historic/NRHP-eligible Historic District Properties to be Mothballed	John W. Evans Solar Facility

Table 5. Alternative 2 – Description of Proposed Activities

	Grain Bin Telescope
	Hilltop Dome
	ISOON Building
	Main Lab
	Storage (3 Quonset Huts)
	Storage 3037
	Machine/Electronics Shop
	Welding Shop/Library
Historic/NRHP-eligible Historic District Properties to be Demolished	Relocatable Housing (21 buildings, including the Recreation House)

Demolition activities for Alternative 2 would be similar to Alternative 1; both involve the potential demolition of 21 contributing resources to the NRHP-eligible historic district (Relocatable Housing, one of which is identified as the Recreation House) but would avoid complete demolition of the historic district. Both individually NRHP-eligible solar telescopes would be retained under Alternative 2; the John W. Evans Solar Facility would be mothballed and DST would be kept in active use and maintained.

Alternative 2 would involve mothballing more historic properties than Alternative 1. Preparations for mothballing historic properties under Alternative 2 would involve the same activities as those described for Alternative 1 and would result in no adverse effects on historic properties under Section 106. Modifications required during mothballing would follow the NPS Preservation Brief 31, “Mothballing Historic Buildings” (Park, 1993). A similar approach would be used for historic instruments and equipment, following guidance in *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* (Grimmer, 2017). If historic properties were returned to use at a future date, alterations performed as part of the mothballing process could be reversed without physical harm to the historic fabric.

Although 21 contributing buildings could be demolished and 11 historic properties could be mothballed (a total of 14 buildings and structures would be mothballed under Alternative 2, but Storage Building 3024, Storage Building 3029, and the Recreation Court are not considered historic properties), which would alter the setting, feeling, and association of the district, it would not be sufficient to render the district ineligible for the NRHP, and Alternative 2 would retain a substantial collection of contributing buildings with sufficient integrity as a group to convey significance in the field of solar astronomy. Alternative 2 would result in greater effects to historic properties than Alternative 1 and fewer significant effects to historic properties than Alternatives 3 and 4.

3.2.2 Operations

Limited site operations would continue under Alternative 2, under the management of an interested party. A total of 11 historic buildings and structures that contribute to the NRHP-eligible historic district would be mothballed, including the John W. Evans Solar Facility that is also individually eligible for listing in the NRHP. Effects to the John W. Evans Solar Facility as a result of the operation of Alternative 2 would be the same as those described for Alternative 1.

Effects to the NRHP-eligible historic district as a result of operation activities for Alternative 2 would be similar to Alternative 1 in that the historic district would retain sufficient integrity to qualify as a historic district. However, under Alternative 2, eight more historic buildings would be mothballed than under Alternative 1, including several solar instruments and administrative buildings. The Hilltop Dome is

currently decommissioned; therefore, operations with the instrument mothballed would not result in a significant change from existing conditions. As described for the John W. Evans Solar Facility and the Grain Bin Telescope under Alternative 1, preserving the Hilltop Dome as a mothballed structure could result in a beneficial effect by ensuring that it is protected, regularly maintained, and kept in working order for future use.

Operations under Alternative 2 would result in a more substantial change to the historic district use and setting than Alternative 1, because several additional properties would be mothballed and removed from active use. Historic properties at the Sacramento Peak Observatory are primarily scientific instruments or utilitarian buildings and their use is a primary component of their significance. Removing a building or structure from use would diminish the historic district's integrity of association and feeling and result in noticeable effects to the historic district. Measures could be implemented to minimize the effects of mothballing the 11 historic properties over time. These measures could include photographic documentation of historic properties, detailed conditions assessment of the historic properties, compliance with certain security and maintenance standards, and regular monitoring of the facilities onsite. Mothballing buildings would be planned and completed in accordance with the NPS Preservation Brief 31, "Mothballing Historic Buildings" (Park, 1993). A similar approach would be used to preserve historic instruments and equipment, following guidance in *The Secretary of the Interior's Standards for the Treatment of Historic Properties* (*with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* (Grimmer, 2017). Operating the facility under Alternative 2 after the demolitions are completed and while 11 other properties are maintained and monitored through mothballing would not substantially alter the characteristics of the remaining Sacramento Peak Observatory historic properties that qualify as eligible for the NRHP and would result in no further adverse effects under Section 106 beyond that incurred under implementation of the alternative described in Section 3.2.1.

3.2.3 Summary of Alternative 2

Alternative 2 involves the potential demolition of historic properties that contribute to the NRHP-eligible historic district. As a result, the overall finding of effect for this Alternative is an adverse effect to historic properties.

3.3 Alternative 3 – Mothballing of Facilities

3.3.1 Implementation

Similar to Alternatives 1 and 2, Alternative 3 involves the potential demolition of facilities at the Sacramento Peak Observatory that contribute to the NRHP-eligible historic district; therefore, Alternative 3 would result in adverse effects under Section 106. Table 6 lists the proposed activities that could affect historic properties under Alternative 3. Any historic property not listed in Table 6 would be kept in active use and maintained.

Table 6. Alternative 3 – Description of Proposed Activities

Historic/NRHP-eligible Historic District Properties to be Mothballed	John W. Evans Solar Facility Grain Bin Telescope Hilltop Dome DST ISOON Building Main Lab Storage (3 Quonset Huts)

Table 6. Alternative 3 – Description of Proposed Activities

	CE Shops (2 Buildings) Equipment Storage/Salt Barn Storage 3037 Weather Station Machine/Electronics Shop Welding Shop/Library Community Center Paint Storage Laundromat Visitor Officers Quarters Redwood Family Housing Duplex Units (3 Buildings) Redwood Family Housing Units (10 Buildings) Emergency Generator Building and Fuel Storage Sewage Treatment Plant (4 Buildings)
Historic/NRHP-eligible Historic District Properties to be Demolished	Relocatable Housing (21 buildings, including the Recreation House)

Under Alternative 3, 38 buildings and structures that contribute to the NRHP-listed historic district, including two telescopes that are individually eligible for the NRHP, would be mothballed and 21 historic properties would be demolished. Four historic buildings and structures that contribute to the NRHP-eligible historic district would be kept in active use and maintained: the Water Tower, the Pump Station Reservoir, and the two Water Well Buildings.

Potential demolition activities for Alternative 3 would be similar to Alternatives 1 and 2, involving the potential demolition of 21 contributing resources to the NRHP-eligible historic district (Relocatable Housing, one of which is identified as the Recreation House) but would avoid complete demolition of the historic district. Both individually NRHP-eligible solar telescopes would be retained and mothballed under Alternative 3.

Alternative 3 would involve mothballing more historic properties than Alternatives 1 and 2. Preparations for mothballing historic properties under Alternative 3 would involve the same activities as those described for Alternatives 1 and 2 and would result in no adverse effects on historic properties under Section 106. Modifications required during the mothballing of buildings would follow the NPS Preservation Brief 31, “Mothballing Historic Buildings” (Park, 1993). A similar approach would be used to preserve and protect historic instruments and equipment, following the guidance in *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* (Grimmer, 2017). If historic properties were returned to use at a future date, alterations performed as part of the mothballing process could be reversed without physical harm to the historic fabric.

Although 21 contributing buildings could be demolished and 38 historic properties would be mothballed, which would alter the setting, feeling, and association of the district, it would not be sufficient to render the district ineligible for the NRHP, and Alternative 3 would retain a substantial collection of contributing buildings with sufficient integrity as a group to convey significance in the field of solar astronomy. (Note: A total of 45 resources would be mothballed under Alternative 3, but 9 of the mothballed resources are not considered historic properties.) Alternative 3 would result in more effects

to historic properties than Alternatives 1 and 2 and fewer effects to historic properties than Alternative 4.

3.3.2 Operations

Operation activities under Alternative 3 would be suspended for an undetermined time frame. However, mothballing would not occur indefinitely, as it is inconsistent with NSF's mission and science priorities. If no viable options are identified for operations to be transferred to a new operator, NSF would consider other methods of disposition and would complete any additional required environmental analysis at that time, if necessary. Under Alternative 3, the NRHP-historic district, including 38 contributing resources (2 of which are also individually NRHP-eligible telescopes), would be mothballed, which would include the removal of each facility from daily use while maintaining the general condition of historic properties for a defined period. Mothballing the primary telescopes – including the individually eligible and still in use DST – and the other contributing facilities at the Sacramento Peak Observatory would significantly alter the use and setting of the site. The John W. Evans Solar Facility and DST are both eligible under Criterion A for important associations with events that have made a significant contribution to the field of solar astronomy. DST is also eligible under Criterion C for design and engineering. Mothballing these two historic structures would not affect their design or engineering, and therefore, would not diminish DST eligibility under Criterion C. However, the structures have achieved significance through their use as tools for furthering the field of solar astronomy. The John W. Evans Solar Facility is not in active use, which has already diminished its integrity of feeling and association, so mothballing the instrument would result in a beneficial effect by maintaining it for future use and avoiding future deterioration. Mothballing the John W. Evans Solar Facility would not alter its eligibility under Criterion A. However, the DST remains in active use and as such, the structure would lose association and feeling if the individually NRHP-eligible telescope were mothballed and taken out of use.

Effects to the NRHP-eligible historic district under Alternative 3 as a result of suspended operations and mothballing historic structures would be similar to those described under Alternative 2 because of a change in use that would affect the historic district integrity of setting and feeling. However, out of the four proposed Alternatives, Alternative 3 would involve mothballing the greatest number of historic properties. The John W. Evans Solar Facility is not in active use, the Grain Bin Telescope has been abandoned, and the Hilltop Dome is decommissioned; therefore, operations with these instruments mothballed would not result in a significant change from existing conditions. As described previously, preserving the John W. Evans Solar Facility, the Grain Bin Dome, and the Hilltop Dome as mothballed structures could result in beneficial effects by ensuring that they are regularly maintained and kept in working order for future use. The temporary suspension of operations under Alternative 3 would result in a more substantial change to the historic district use and setting than Alternatives 1 and 2. Only four infrastructure-related buildings and structures that contribute to the NRHP-eligible historic district would be kept in active use and maintained. The same measures that were described for Alternative 2 could be implemented to minimize the effects on historic buildings from suspending use and mothballing (Park, 1993; Grimmer, 2017). Under Alternative 3, operations would be suspended, but this would not significantly alter characteristics of the NRHP-eligible historic district or contributing elements that qualify as eligible for the NRHP and would result in no further adverse effects under Section 106 beyond that incurred under implementation of the alternative described in Section 3.3.1.

3.3.3 Summary of Alternative 3

Alternative 3 involves the demolition of historic properties that contribute to the NRHP-eligible historic district. As a result, the overall finding of effect for this Alternative is an adverse effect to historic properties.

3.4 Alternative 4 – Demolition and Site Restoration

3.4.1 Implementation

Alternative 4 would involve the demolition of 59 historic properties that contribute to the NRHP-eligible historic district (which includes two telescopes that are also individually NRHP-eligible), resulting in adverse effects on historic properties under Section 106. Table 7 lists the proposed activities that would affect historic properties under proposed Alternative 4. Any historic property not listed in Table 7 would be kept in active use and maintained.

Table 7. Alternative 4 – Description of Proposed Activities

Historic/NRHP-eligible Historic District Properties to be Demolished	John W. Evans Solar Facility Grain Bin Telescope Hilltop Dome DST ISOON Building (Patrol Dome) Main Lab Storage (3 Quonset Huts) CE Shops (2 Buildings) Equipment Storage/Salt Barn Storage 3037 Weather Station Machine/Electronics Shop Welding Shop/Library Community Center Paint Storage Laundromat VOQ Redwood Family Housing Duplex Units (3 Buildings) Redwood Family Housing Units (10 Buildings) Relocatable Housing (21 Buildings, including the Recreation House) Emergency Generator Building and Fuel Storage Sewage Treatment Plant (4 Buildings)

Alternative 4 would involve the demolition of most of the NRHP-listed historic district, resulting in adverse effects on historic properties under Section 106. Under Alternative 4, the primary solar telescopes and administrative buildings would be demolished. Only four historic properties would remain extant: the Water Tower, two Water Well Buildings, and the Pump Station Reservoir. The four contributing buildings that would remain are part of the site infrastructure and are not defining elements of the NRHP-eligible district. As a result of the demolition of all solar instruments and research support facilities within Sacramento Peak Observatory, the historic district would lose integrity of materials, design, workmanship, feeling, association, and setting. As a result, demolition under Alternative 4 would result in a significant loss of integrity for the remaining structures, and the historic district would no longer retain sufficient integrity to be considered eligible for the NRHP. Therefore, of the four proposed Alternatives, Alternative 4 would have the greatest effects to historic properties.

3.4.2 Operations

Operations would completely cease under Alternative 4; therefore, operation of Alternative 4 would result in no further effects to historic properties beyond that incurred under implementation of the alternative described in Section 3.4.1.

3.4.3 Summary of Alternative 4

Alternative 4 involves the demolition of nearly all historic properties that contribute to the NRHP-eligible historic district. As a result, the overall finding of effect for the alternative is adverse effect to historic properties.

3.5 No-Action Alternative

Under the No-Action Alternative, current activities would continue at the Sacramento Peak Observatory, and no mothballing or demolition would occur. Current activities at the Sacramento Peak Observatory include regular maintenance of buildings and structures, and alterations to resources that are individually eligible for the NRHP or that contribute to the NRHP-eligible historic district to adapt to changes in science and technology. Therefore, maintaining the current conditions of the Sacramento Peak Observatory could involve minor alterations to historic properties to retain their utility; however, a review of proposed alterations would occur prior to action being taken to determine if there are effects on NRHP-listed properties. No proposed alterations are currently pending and, therefore, the No-Action Alternative would result in no adverse effect on historic properties.

SECTION 4

Conclusion

The Sacramento Peak Observatory is eligible for listing in the NRHP as a historic district with 63 contributing resources. Under Alternatives 1, 2, 3, and 4, historic properties that contribute to the NRHP-eligible historic district could be demolished, resulting in a finding of adverse effect under Section 106. Under the No-Action Alternative, there would be no change from the existing conditions and a finding of no adverse effect to historic properties. The finding of effect for each Alternative is summarized in Table 8.

Table 8. Summary of Effects to Historic Properties

Alternative	Finding of Effect [a]
Alternative 1	Adverse Effect
Alternative 2	Adverse Effect
Alternative 3	Adverse Effect
Alternative 4	Adverse Effect
No-Action Alternative	No Adverse Effect

[a] Pending concurrence from SHPO.

When an undertaking is found to have an adverse effect, Section 106 requires consultation with SHPO and other Consulting Parties regarding appropriate avoidance, minimization, or mitigation measures. The product of consultation would be an MOA per 36 C.F.R. §800.6(c) or a PA per 36 C.F.R. §800.14(b) between the SHPO, NSF, and possibly other Consulting Parties. NSF will continue to consult with the New Mexico SHPO and other Consulting Parties to determine the appropriate ways in which to avoid, minimize, and/or mitigate any adverse effects.

SECTION 5

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Appendix A
Evaluated Architectural Resources

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Surveyed Building/Structure Name (Building Number) *	Year Built	Description	Function	Alterations/Additions	NRHP Status	Contributing to Historic District?
TELESCOPES						
Grain Bin Dome (3002)	1950	First telescope dome built at Sac Peak; 25-foot grain silo, converted from a grain bin from a Sears and Roebuck catalogue	Solar telescope (not in active use)	Alterations: interior changes to accommodate various telescopes	Not Individually Eligible	Contributing
John W. Evans Solar Facility [housed in the Big Dome] (3000)	1952	30-foot dome on concrete walls, concrete block building adjacent and a "slide-off" building on raised tracks; contains a 16-inch coronograph and a 12-inch coelostat	Solar telescope (not in active use)	Alterations: interior alterations to accommodate various telescopes; dome door system changed (1959); Additions: west addition (1961), second west addition (1963), laboratory space added (1966)	Individually Eligible	Contributing
Patrol Dome (ISOON Building) (3009)	1960-1963	20-foot dome on concrete wall attached with a one-story hyphen to the Hilltop Dome	Solar telescope (not in active use)	Addition: dome was originally detached from the Hilltop building. Connecting corridor was added.	Not Individually Eligible	Contributing
Hilltop Dome (3040)	1963	Concrete block laboratory building attached to the Patrol Dome	Solar telescope (not in active use)	Addition: Hilltop building was originally detached from the Patrol Dome. Connecting corridor was added.	Not Individually Eligible	Contributing
Richard B. Dunn Solar Telescope (DST), formerly Vacuum Tower Telescope (3042)	1969	136-foot tower, 220-foot shaft below ground, concrete walls and an attached, two-story, concrete laboratory building with a thermal plastic vinyl roof	Solar telescope	Additions: small metal shed addition and larger concrete block shed addition on the rear elevation; windows have been covered with an opaque material	Individually Eligible	Contributing
HOUSING						
Visitor Officers Quarters (VOQ) (3013)	1952	Two-story wood frame apartment building with 5 apartments	Residential	Alterations: minor interior	Not Individually Eligible	Contributing
Redwood Family Housing (3014ns)	1952	One-story wood frame duplex	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing (also known as Director's House) (3015)	1952	One-story wood frame ranch house	Residential	Additions: expanded living room, added deck and extra bedroom	Not Individually Eligible	Contributing
Redwood Family Housing (3016ns)	1952	One-story wood frame duplex	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing (3017)	1952	One-story wood frame ranch house	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing (3018)	1952	One-story wood frame ranch house	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing (3019)	1952	One-story wood frame ranch house	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing (3020ns)	1952	One-story wood frame duplex	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing on Hound Dog Hill (3044)	1958	One-story wood frame ranch house	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing on Hound Dog Hill (3045)	1958	One-story wood frame ranch house	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing on Hound Dog Hill (3046)	1958	One-story wood frame ranch house	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing on Hound Dog Hill (3047)	1958	One-story wood frame ranch house	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing on Hound Dog Hill (3048)	1958	One-story wood frame ranch house	Residential	Alterations: minor	Not Individually Eligible	Contributing
Redwood Family Housing on Hound Dog Hill (3049)	1958	One-story wood frame ranch house	Residential	Alterations: minor	Not Individually Eligible	Contributing
Relocatable Housing (3061)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3062)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3063)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3064)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3065)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3066)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing

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Relocatable Housing (3067)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3068)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3069)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3070) (also known as the Recreation House)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3071)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3072)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3073)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3074)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3075)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3076)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3077)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3079)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3081)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3083)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
Relocatable Housing (3085)	1966	One-story, "foldable," ranch house	Residential	N/A	Not Individually Eligible	Contributing
ADMINISTRATIVE BUILDINGS						
Main Lab (3004)	1952	Irregular plan, one-story, concrete block building with a two-story, concrete block addition	Office space, computing facility, library	Alterations: door replacements; minor alterations to several windows Addition: Two-story laboratory space added (1966)	Not Individually Eligible	Contributing
Machine/Electronics Shop (3005)	1953	Rectangular plan, metal building	Machine/electronics shop	Alterations: original flat roof replaced with a gabled roof. Additions: north addition and full length addition to east elevation	Not Individually Eligible	Contributing
Welding Shop/Library (3006)	1962	Rectangular plan, metal building	Welding shop/library annex	Addition: library at the north end of the building was an addition to the welding shop	Not Individually Eligible	Contributing
Storage (Quonset Hut) (3008)	1951	Quonset hut on concrete slab	Electronics storage	N/A	Not Individually Eligible	Contributing
Community Center (former Mess Hall) (3010)	1952	One-story, wood frame building	Kitchen, office space, community center (originally contained the post office, officer's club, and dining facilities)	N/A	Not Individually Eligible	Contributing
Storage (Quonset Hut) (3011)	1951	Quonset hut on concrete slab	Facilities maintenance storage	Alterations: several windows have been replaced	Not Individually Eligible	Contributing
Storage (Quonset Hut) (3012)	1951	Quonset hut on concrete slab	Community shop, storage	Alterations: several windows have been replaced or covered with metal	Not Individually Eligible	Contributing
Storage Building (3024)	1958	Metal frame shed	Storage	N/A; poor condition	Not Individually Eligible	Non Contributing
Furniture Storage (Quonset Hut) (3029)	1951	Quonset hut on concrete slab	Furniture storage	Alterations: side windows have been covered with opaque boards; some siding has been replaced; poor condition	Not Individually Eligible	Non Contributing

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Surveyed Building/Structure Name (Building Number) *	Year Built	Description	Function	Alterations/Additions	NRHP Status	Contributing to Historic District?
Civil Engineering (CE) Shop (3031)	1953	One-story concrete block and plywood building with flat roof	Carpentry, welding, electrical shops	Alterations: Open front elevation was enclosed at an unknown date	Not Individually Eligible	Contributing
CE Shop (3032)	1953	Long, one-story, concrete block building	Facilities shops	Addition; one bay garage added for firetruck storage along with a small rear apartment	Not Individually Eligible	Contributing
Paint Storage (3034)	1959	Small concrete block building	Paint/hazardous waste storage	Alterations: replacement doors	Not Individually Eligible	Contributing
Equipment Storage/Salt Barn (3036)	1961	Wood frame, metal shed, dirt floor	Equipment storage	N/A	Not Individually Eligible	Contributing
Storage (3037)	1953	Concrete block	Facilities maintenance storage	N/A	Not Individually Eligible	Contributing
Emergency Generator Building (3038)	1962	Concrete block building on a raised concrete foundation	Emergency generator room	Alterations: two windows on front elevation have been replaced with louvered metal vents	Not Individually Eligible	Contributing
Weather Station (3039)	1955	One-story, square plan, concrete block building with a flat roof	Weather station/storage	Alterations: several window panes have been replaced with opaque materials	Not Individually Eligible	Contributing
Laundromat [formerly public restrooms] (3060)	circa late 1950s	One-story concrete block building	Laundromat, custodial storage	Alterations: minor interior alterations; two windows replaced	Not Individually Eligible	Contributing
INFRASTRUCTURE						
Pump Station Reservoir (3033)	1953	Concrete block building with two 10,000-gallon concrete, ground-level storage tanks	Reservoir	Addition: metal shed	Not Individually Eligible	Contributing
Water Well Building (3050)	1953	Metal frame sheds with aluminum siding	Water well	N/A	Not Individually Eligible	Contributing
Water Well Building (3051)	1953	Metal frame sheds with aluminum siding	Water well	N/A	Not Individually Eligible	Contributing
Sewage Treatment Plant - Boiler Room (3053)	1953	Small concrete block building clad in wide, wood drop siding, mineral surface roof	Treatment plant	Alterations: replacement of a window and some exterior materials	Not Individually Eligible	Contributing
Sewage Treatment Plant - Trickling Filter (3054)	1957	Small concrete block shed with a corrugated metal gable roof	Trickling filter	Alterations: replacement window	Not Individually Eligible	Contributing
Sewage Treatment Plant - Valve Station (3055)	1961	Metal frame building with a corrugated metal roof	Valve station	N/A	Not Individually Eligible	Contributing
Sewage Treatment Plant - Pump Station (3056)	1966	Small metal frame building with a corrugated metal roof	Pump station	N/A	Not Individually Eligible	Contributing
Overhead Water Tower (no building number)	1952	120-foot tall, 25,000-gallon steel elevated water tank	Water tower	Alterations: internally recoated in the last 5 years	Not Individually Eligible	Contributing

* This table only includes resources that were inventoried as part of the 2015 cultural resources survey. Buildings and structures that were not 45 years old at the time of the cultural resources survey, were not considered to have exceptional importance, or were not owned by NSF were not included in the historic district evaluation.